StorageTek T10000 Tape Drive

Fibre Channel Interface Reference Manual

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Preface

The *Fibre Channel Interface Reference Manual* is intended for independent software vendors (ISVs) plus operating system designers and developers implementing Fibre Channel on Oracle's StorageTek T10000 Tape Drive.

This manual is also intended for solutions delivery engineers, systems engineers; plus hardware, software, and service representatives.

This manual describes information about the StorageTek T10000*A,* T10000*B,* T10000C, and T10000D Tape Drives. Unless otherwise specified, this information pertains to all models of the T10000. Where information changes, the following is used to identify them:

- 2FC = T10000*A* with a 2 Gb interface
- 4FC = T10000*A* or T10000*B* or T10000C with a 4 Gb interface
- 16FC = T10000D
- 10FCoE = T10000D
- T10000A or T10000B or T10000C or T10000D
- FC = Fibre Channel
- FCoE = Fibre Channel over Ethernet

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What's New

Information added about the T10000D tape drive.

Information added about the T10000D tape drive support of the T10 Protection Information feature.

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General Information

This chapter contains an overview about the Fibre Channel specifications for Oracle’s StorageTek T10000 Tape Drive, which conforms to the:

- American National Standards Institute (ANSI)
- National Committee for Information Technology Standards (NCITS)

TABLE 1-1 lists the documents that help define this implementation.

TABLE 1-1 Fibre Channel Reference Documentation

Specification	Revision
Fibre Channel Physical and Signaling Interface	FC-PH X3.230: 1994
Fibre Channel Physical and Signaling Interface 2nd Generation	FC-PH-2 X3.297: 1997
Fibre Channel Physical and Signaling Interface 3rd Generation	FC-PH-3 X3.303:1998
2FC* Fibre Channel Arbitrated Loop	FC-AL X3.272-1996 Rev. 4.5
2FC* Fibre Channel Arbitrated Loop 2 (August 28, 1998)	FC-AL-2 Working Draft Rev. 6.4
4FC* Fibre Channel Physical Interface	FC-PI T11/Project 1306-0, Rev. 2
4FC* Fibre Channel Framing and Signaling Interface	ANSI/INCITS:373:2003
Fibre Channel Framing and Signaling Interface 2	ANSI/INCITS:424:2007
Fibre Channel Framing and Signaling Interface 3	FC-FS-3 T11/1861-D Rev 1.11
FCoE - FC-BB-5	ANSI/INCITS:462:2010
16FC* Fibre Channel Physical Interfaces 5	ANSI/INCITS:479:2011
Fibre Channel - Link Services	ANSI/INCITS:433:2006
Fibre Channel - Link Services - 2	ANSI/INCITS:477:2011
Fibre Channel Fabric Loop Attachment Technical Report	FC-FLA NCITS/TR-20: 1998
Fibre Channel Private Loop Direct Attach Technical Report	FC-PLDA NCITS/TR-19: 1998
Fibre Channel Generic Services Definition 2nd Generation	FC-GS-2 NCITS 288.200x, Rev. 5.3
Fibre Channel Generic Services Definition 3rd Generation	FC-GS-3 Working Draft Rev. 6.2
Fibre Channel Tape Profile Technical Report (May 14, 1999)	FS-Tape T11/99-069v4, Rev. 1.17

* Indicates specific reference for that implementation of the Fibre Channel interface.

TABLE 1-1 Fibre Channel Reference Documentation (Continued)

Specification	Revision
SCSI Fibre Channel Protocol	SCSI FCP X3.269:1996, Rev. 12
SCSI Fibre Channel Protocol 2	ANSI NCITS:350:2003
SCSI Fibre Channel Protocol 3	ANSI INCITS:416:2006
SCSI–3 Architecture Model (SAM-2)	ANSI NCITS:366:2003
SCSI-3 Architecture Model (SAM-3)	ANSI INCITS:402:2005
SCSI–3 Primary Commands (SPC–2)	ANSI NCITS:351:2001
SCSI-3 Primary Commands (SPC-3)	ANSI NCITS:408:2005
SCSI–3 Stream Commands (SSC)	ANSI NCITS:335:2000
SCSI-3 Stream Commands (SSC- 4)	T10/2123-D Revision 02

* Indicates specific reference for that implementation of the Fibre Channel interface.

Overview

- Serial connection
- Copper (electrical) or fiber (optical) transmissions
- Multiple protocols (such as SCSI, IP, HIPPI, IPI-3)
- Information transparent
- 100 – 1600 MB data transfer rates
- Scalable for data rates, distance, media, and protocols

In 1994, the Fibre Channel Physical and Signaling Interface (FC–PH), or ANSI X3.230–1994, was completed, differing from every other architecture at the time. This specification married the strengths of channels, including high throughput and low overhead, with the strengths of networks, including flexibility, long distance capability, and high connectivity.

See TABLE 1-2 for a description of the Fibre Channel layers.

TABLE 1-2 Fibre Channel Layers

ULPs	SCSI	IPI	IP	SBCCS	HIPPI
FC-4	• Upper Level Protocol Mapping • Mapping of ULP functions and constructs				
FC-3	Common Services				
FC-2	Link Service • Login and Logout services • Basic and Extended Link services Signaling Protocol • Frames, Sequences, and Exchanges • N_Ports, F_Ports, and Topologies • Classes of Service (1, 2, and 3) • Buffer-to-Buffer/end-to-end flow control				
FC-AL	Arbitrated Loop Functions • Ordered sets for loop arbitration • Loop Initialization • Physical address assignments				
FC-1	Transmission Protocol • Encoding and Decoding • Link management • Error monitoring				
FC-0	Physical Interface • Transmitters, receivers, and Bandwidth Media • Cables and Connectors				

Tape Drive Description

Size: The T10000 tape drive is a small, modular, high-performance tape drive designed for high-capacity storage of data. The drive is:

- Height = 8.89 cm (3.5 in.)
- Width = 14.6 cm (5.75 in.)
- Depth = 42.5 cm (16.75 in.)

Capacity: The T10000 uses a technology called partial response, maximum likelihood (PRML) to provide the high-density data format that allows the tape drive to record and store up to:

- T10000A = 500 gigabytes (GB) of uncompressed data.
- T10000B = 1 terabyte (TB) of uncompressed data.
- T10000C = 5 terabytes (TB) of uncompressed data.
- T10000D = 8 terabytes (TB) of uncompressed data.

Media: The new tape cartridge for this drive uses a single-reel hub for high capacity; the supply reel is inside the cartridge and the take-up reel is inside the tape drive.

Interface: The host connections to the T10000 are fiber-optic to provide a high rate of data transfer, such as Fibre Channel and FICON.

Configurations: The T10000 supports two configurations: library and stand-alone, for a variety of operating system platforms:

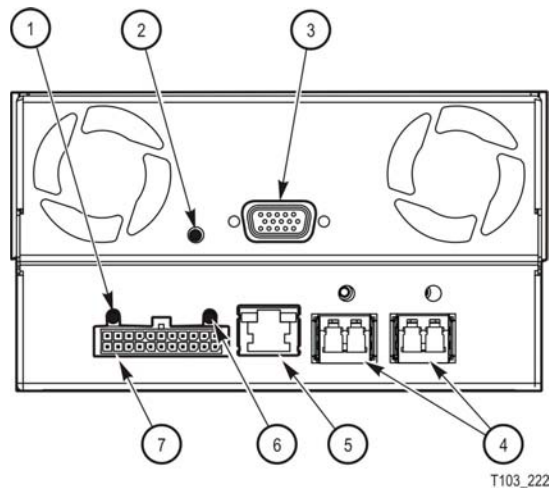
- Enterprise mainframes (z/OS and OS/390)
- Open system platforms (Windows, UNIX, and Linux)

FIGURE 1-1 on page 23 shows a rear view of the T10000A and T10000B tape drive.

FIGURE 1-2 on page 23 shows a rear view of the T10000C tape drive.

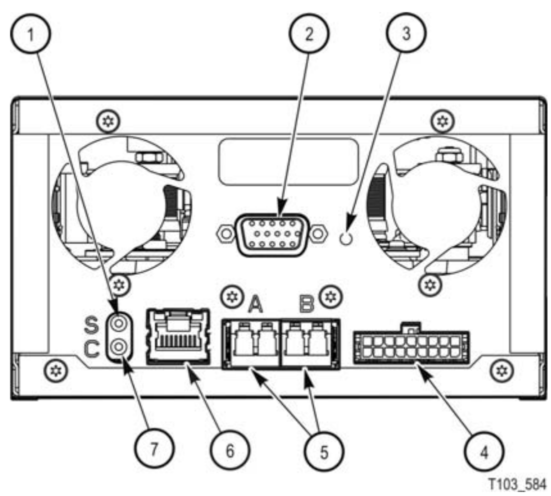
FIGURE 1-3 on page 24 shows a rear view of the T10000D tape drive.

FIGURE 1-1 T10000A and T10000B Tape Drive Rear View



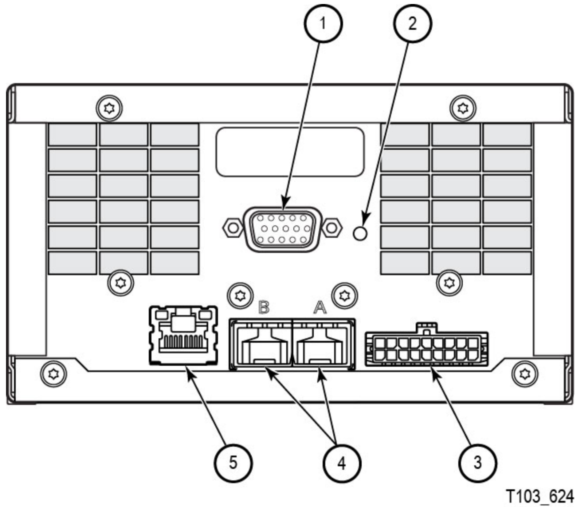
1. Drive status LED
2. Recessed switch (service only)
3. Tape transport interface (TTI) connector
4. Fibre Channel, LC interface ports (2) A & B
5. Ethernet port
6. Encryption status LED
7. Power supply connector

FIGURE 1-2 T10000C Tape Drive Rear View



1. Drive status LED
2. Tape transport interface (TTI) connector
3. Recessed switch (service only)
4. Power supply connector
5. Fibre Channel, LC interface ports (2) A & B
6. RJ-45 Ethernet connector
7. Encryption status LED

FIGURE 1-3 T10000D Tape Drive Rear View



1. Tape transport interface (TTI) connector
2. Recessed switch (service only)
3. Power supply connector
4. Fibre Channel, LC interface ports (2) A & B
5. RJ-45 Ethernet connector

Specifications

This section lists the physical, environmental, and performance specifications for the T10000 tape drive.

TABLE 1-3 T10000A and T10000B Tape Drive Performance Specifications

Characteristic	Specification
Capacity and Performance	
T10000A Capacity, native	500 GB (5 x 10^{11} bytes)
T10000A Sport Cartridge, native	120 GB
T10000B Capacity, native	1 TB (1 x 10^{12} bytes)
T10000B Sport Cartridge, native	240 GB
Data buffer size	256 MB
Tape speeds:	
Read and write	2.0 and 4.95 m/s
File search and locates	8.0 m/s
High speed rewind	9.5 m/s
Interfaces	
Types	2FC = 1, 2 Gb Fibre Channel and FICON 4FC = 1, 2, 4 Gb Fibre Channel and FICON
Support	2FC = N_Port and NL_Port 4FC = N_Port only
Data rate (uncompressed)	120 MB/s
Compressed (maximum)	2FC = 180 MB/s 4FC = 360 MB/s
Burst transfer rate	2FC = 200 MB/s 4FC = 400 MB/s
Channel rate (Fibre Channel)	2FC = 1.0625 and 2.125 Gb/s 4FC = 1.0625, 2.125, and 4.250 Gb/s
Emulation Modes	3592 (MVS) and 3490 (VSM)
Access times	
Tape load and thread to ready	16 s
File access (includes loading)	62 s
Rewind (maximum)	91 s 23 s with the Sport cartridge
Unload time	23 s

TABLE 1-4 T10000C Tape Drive Performance Specifications

Characteristic	Specification
Capacity and Performance	
T10000C Capacity, native	5 TB (5 X 10^{12} bytes)
T10000C Sport Cartridge, native	1 TB
Data buffer size	2 GB
Tape speeds:	
Read and write	3.7 and 5.6 m/s
File search and locates	13 m/s
High speed rewind	13 m/s
Interfaces	
Types	4FC = 1, 2, 4 Gb Fibre Channel and FICON
Support	4FC = N_Port and NL_Port
Data rate (uncompressed)	240 MB/s
Compressed	4FC = 360 MB/s
Burst transfer rate	4FC = 400 MB/s
Channel rate (Fibre Channel)	4FC = 1.0625, 2.125, and 4.250 Gb/s
Emulation Modes	3592 (MVS) and 3490 (VSM)
Access times	
Tape load and thread to ready	16 s
File access (includes loading)	57 s
Rewind (maximum)	115 s 32.5 s with the Sport cartridge
Unload time	23 s

TABLE 1-5 T10000D Tape Drive Performance Specifications

Characteristic	Specification
Capacity and Performance	
T10000D Capacity, native	8 TB (8 X 10^{12} bytes)
T10000D Sport Cartridge, native	1.6 TB
Data buffer size	2 GB
Tape speeds:	
Read and write	2.75, 3.25, 3.75, 4.25, 4.75 m/s
File search and locates	13 m/s
High speed rewind	13 m/s
Interfaces	
Types	16FC = 4, 8, 16 Gb Fibre Channel and FICON
	10FCoE = 10 GbE
Support	4Gb = N_Port and NL_Port 8Gb = N_Port and NL_Port 16Gb = N_Port only
Native sustained data rate (uncompressed) up to	254 MB/s
Compressed up to	16FC = 818 MB/s
	10FCoE = 812 MB/s
Burst transfer rate up to	16FC = 1,600 MB/s 10FCoE = 1,000 MB/s
Channel rate (Fibre Channel)	16FC = 4.250, 8.5, 14.025 Gb/s
(Ethernet)	10FCoE = 10 Gb/s
Emulation Modes	FICON 3592 (MVS) and 3490 (VSM)
Access times	
Tape load and thread to ready	13 s
File access (includes loading)	50 s
Rewind (maximum)	97 s with Standard cartridge 26 s with Sport cartridge
Unload time	23 s

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Operations

This chapter describes how StorageTek tape drives operate using a Fibre Channel (FC) interface.

Note – This document is defined by the requirements in FC-Tape Revision 1.17. As updates occur to the FC-Tape document, this document will be updated accordingly.

Connections

The T10000 tape drives support various connections:

- 2FC = Direct N_Port, Arbitrated Loop, and a Fabric
- 4FC = Direct N_Port, Arbitrated Loop, and a Fabric
- 8FC = Direct N_Port, Arbitrated Loop, and a Fabric
- 16FC = Direct N_Port, and a Fabric

Arbitrated Loop

An arbitrated loop provides multiple connections for devices that share a single loop, but only provides point-to-point connections between an initiator and target during communications.

Note – Both public loops and private loops are supported.

As with SCSI protocol, when devices want to communicate on the bus, they must arbitrate and win the connection before communications can begin. The same goes with the arbitrated loop. Once a device is powered-on and initialized on the loop, it must arbitrate and win to be able to communicate with other devices on the loop.

Fabric Attachment

Fabric, or F_Ports, provide “direct” attachments to the tape drives. The Fabric receives frames from a source N_Port and routes them to a destination N_Port whose address identifier is specified within the frame.

Direct N_Port Attachment

The T10000 tape drives support direct attachment to a host through a host bus adapter (HBA) that creates an N-Port. The HBA sends and receives to and from the tape drive.

Addressing

StorageTek tape drives use: Port name, Node name, and Port ID for login validation. The StorageTek registration ID is 24 bits consisting of:

- 00104F (hex)

TABLE 2-1 indicates the Institute of Electrical and Electronics Engineers (IEEE) registered format for Name Address Authority (NAA), company ID, and vendor specific identifier for a total of 64 bits.

TABLE 2-1 Addressing Scheme

Most Significant Bit		**Least Significant Bit**
63 60	59 36	35 00
NAA	IEEE Company ID	Vendor Specific Identifier
"0101" (b)	**00 10 4F** (hex)	(to be assigned)

All ports validate the logins by comparing Port Name, Node Name, and Port ID. All three identifiers must match or this indicates the configuration has changed and requires a Logout (LOGO).

> **Note –** A LOGO terminates all open Exchanges between SCSI initiator and target.

SCSI Features

The following sections describe the SCSI features supported by the tape drives.

Auto Contingent Allegiance

StorageTek tape drives do not support Auto Contingent Allegiance (ACA).

Asynchronous Event Notification

StorageTek tape drives do not support asynchronous event notification (AEN).

Command Linking

StorageTek tape drives do not support Command Linking. The Link and Flag bits of the Command Descriptor Block must be set to zero.

Status Byte

The target returns a status byte to the initiator at the completion of each command during the Status phase unless the command is cleared or interrupted. The tape drives support five status byte codes:

- Busy
- Check Condition
- Good
- Reservation Conflict
- Task Set Full

Busy

Busy (08) status occurs when the target:

- Is busy performing another operation
- Cannot accept a command

The normal initiator recovery from a Busy status is to reissue the command.

Check Condition

Check Condition (02) status occurs when any error, unit exception, or abnormal condition that generates sense data occurs.

Check Condition status occurs when one of the following conditions exist:

- Issuing an invalid command or parameter
- Issuing a motion command to a device that is not ready
- Issuing a write-type command to a file-protected cartridge
- Issuing a forward motion command to a device at the physical end-of-tape
- Issuing a backspace operation to a device at the beginning-of-tape
- Detecting a deferred check condition
- Exceeding the retry operations for an interface error
- Detecting any error condition that prevents successful completion of an operation

Good

Good (00) status indicates that the device successfully completed the command.

Reservation Conflict

Reservation Conflict (18) status is returned whenever a SCSI initiator attempts an operation that violates another initiator's Logical Unit Reservation.

Task Set Full

Task Set Full (28) status is returned when the logical unit receives a command and does not have enough resources to process it.

Device Reservations

The T10000 tape drives support the Reserve/Release management method and also the Persistent Reservations management method. These methods are defined in the ANSI SCSI-3 Primary Commands (SPC-2) standard.

- See TABLE 2-2 for the reservation restrictions placed on commands for the Reserve/Release management method.
- See TABLE 2-3 on page 35 for the reservation restrictions placed on the Persistent Reservations management method.

Each method lists the type of restriction for the command being performed:

Conflict
Command will not be performed and the drive will terminate the command with Reservation Conflict status.

Allowed
Command will be allowed to execute to normal completion.

TABLE 2-2 Reserve/Release Management Method

Command	Action when Reserved by a different Initiator
Erase (19h)	Conflict
Inquiry (12h)	Allowed
Load Display (06h)	Conflict
Load/Unload (1Bh)	Conflict
Locate (2Bh)	Conflict
Log Select (4Ch)	Conflict
Log Sense (4Dh)	Allowed
Mode Select (15h/55h)	Conflict
Mode Sense (1Ah/5Ah)	Conflict
Persistent Reserve In (5Eh)	Conflict
Persistent Reserve Out (5Fh)	Conflict
Prevent/Allow Removal (1Eh)	Prevent = 0, allowed Prevent = NZ, conflict
Read (08h)	Conflict
Read Attribute (8Ch)	Conflict
Read Block Limit (05h)	Allowed
Read Buffer (3Ch)	Conflict
Read Media Serial Number (ABh–01h)	Allowed
Read Position (34h)	Conflict
Read T10 PI (98h)	Conflict
Receive Diagnostic Results (1Ch)	Conflict

TABLE 2-2 Reserve/Release Management Method (Continued)

Command	Action when Reserved by a different Initiator
Release Unit (17h/57h)	Allowed, the reservation is not released.
Report Density Support (44h)	Allowed
Report LUNs (A0h)	Allowed
Report Supported Operations Codes (A3h–0Ch)	Conflict
Report Supported Task Management Functions (A3h–0Dh)	Conflict
Report Target Port Groups (A3h–0Ah)	Allowed
Request Sense (03h)	Allowed
Reserve Unit (16h/56h)	Conflict
Rewind (01h)	Conflict
Send Diagnostic (1Dh)	Conflict
Space (11h)	Conflict
Spin (A2h)	Conflict
Spout (B5h)	Conflict
Test Unit Ready (00h)	Conflict
Verify (13h)	Conflict
Write (0Ah)	Conflict
Write Buffer (3Bh)	Conflict
Write Filemarks (10h)	Conflict
Write T10 PI (9Ah)	Conflict

TABLE 2-3 lists the reservation restrictions placed on the Persistent Reservations management method.

TABLE 2-3 Persistent Reservation Management Method

Command	From Non-registered Initiators	From Registered Initiators
Erase (19h)	Conflict	Allowed
Inquiry (12h)	Allowed	Allowed
Load Display (06h)	Conflict	Allowed
Load/Unload (1Bh)	Conflict	Allowed
Locate (2Bh)	Conflict	Allowed
Log Select (4Ch)	Conflict	Allowed
Log Sense (4Dh)	Allowed	Allowed
Mode Select (15h/55h)	Conflict	Allowed
Mode Sense (1Ah/5Ah)	Conflict	Allowed
Persistent Reserve In (5Eh)	Allowed	Allowed
Persistent Reserve Out (5Fh)	Register, allowed Reserve, conflict Release, conflict Clear, conflict Pre-empt, conflict Pre/Abt, conflict	Register, allowed Reserve, conflict Release, allowed Clear, allowed Pre-empt, allowed Pre/Abt, allowed
Prevent/Allow Media Removal (1Eh)	Prevent = 0, allowed Prevent = NZ, conflict	Allowed
Read (08h)	Conflict	Allowed
Read Attribute (8Ch)	Conflict	Allowed
Read Block Limit (05h)	Allowed	Allowed
Read Buffer (3Ch)	Conflict	Allowed
Read Media Serial Number (ABh–01h)	Allowed	Allowed
Read Position (34h)	Conflict	Allowed
Read T10 PI (98h)	Conflict	Allowed
Receive Diagnostic Results (1Ch)	Conflict	Allowed
Release Unit (17h/57h)	Conflict	Allowed, reservation is not released
Report Density Support (44h)	Allowed	Allowed
Report LUNs (A0h)	Allowed	Allowed
Report Supported Operations Codes (A3h–0Ch)	Conflict	Allowed
Report Supported Task Management Functions (A3h–0Dh)	Conflict	Allowed

TABLE 2-3 Persistent Reservation Management Method (Continued)

Command	From Non-registered Initiators	From Registered Initiators
Report Target Port Groups (A3h–0Ah)	Allowed	Allowed
Request Sense (03h)	Allowed	Allowed
Reserve Unit (16h/56h)	Conflict	Allowed, reservation is not changed
Rewind (01h)	Conflict	Allowed
Send Diagnostic (1Dh)	Conflict	Allowed
Space (11h)	Conflict	Allowed
Spin (A2h)	Conflict	Allowed
Spout (B5h)	Conflict	Allowed
Test Unit Ready (00h)	Conflict	Allowed
Verify (13h)	Conflict	Allowed
Write (0Ah)	Conflict	Allowed
Write Buffer (3Bh)	Conflict	Allowed
Write Filemarks (10h)	Conflict	Allowed
Write T10 PI (9Ah)	Conflict	Allowed

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Commands

This chapter defines the SCSI-3 commands for the StorageTek T10000 Tape Drive with a Fibre Channel interface.

Overview

StorageTek uses the SCSI-3 command set to transfer commands and data over Fibre Channel. The following describes how StorageTek implements these SCSI commands:

- A single command may transfer one or more logical blocks of data.
- The target may disconnect from the arbitrated loop to allow activity by other SCSI devices while a device prepares to transfer data.
- On completion of normal commands (successful or unsuccessful), the target returns a Status Byte to the initiator. Because most error and exception conditions cannot be adequately described with a single status byte, a Check Condition status code indicates that additional information is available in the FCP Response Information Unit (IU).
- An initiator should never attempt to send a second command to a device until the command in progress ends. The second command terminates with a Check Condition status (Command Overrun).

Commands

TABLE 3-1 lists the supported commands and references the appropriate page.

TABLE 3-1 Supported SCSI Commands

Command	Code	Reference	Page
Erase	19h	SSC	43
Inquiry	12h	SPC-2	48
Load Display	06h	Vendor specific	57
Load/Unload	1Bh	SSC	59
Locate	2Bh	SSC	60
Log Select	4Ch	SPC-2	63

TABLE 3-1 Supported SCSI Commands (Continued)

Command	Code	Reference	Page
Format Medium	04h	SSC-3	47
Log Sense	4Dh	SPC-2	64
Mode Select	15h / 55h	SPC-2	91
Mode Sense	1Ah / 5Ah	SPC-2	111
Persistent Reserve In	5Eh	SPC-2	131
Persistent Reserve Out	5Fh	SPC-2	136
Prevent/Allow Media Removal	1Eh	SSC	140
Read	08h	SSC	141
Read T10 PI	98H	SSC-5	144
Read Attribute	8Ch	SPC-4	146
Read Block Limits	05h	SSC	155
Read Buffer	3Ch	SPC-2	156
Read Media Serial Number	ABh – 01h	SPC-3	158
Read Position	34h	SSC	159
Receive Diagnostic Results	1Ch	SPC-2	165
Release Unit	17h / 57h	SPC-2	170
Report Density Support	44h	SSC	171
Report LUNs	A0h	SPC-2	176
Report Supported Operation Codes	A3h – 0Ch	SPC-4	177
Report Supported Task Management Functions	A3h – 0Dh	SPC-4	183
Report Target Port Groups	A3h – 0Ah	SPC-4	185
Request Sense	03h	SPC-2	189
Reserve Unit	16h / 56h	SPC-2	200
Rewind	01h	SSC	201
Security Protocol In (SPIN)	A2h	SSC-3	202
Security Protocol Out (SPOUT)	B5h	SSC-3	217
Send Diagnostic	1Dh	SPC-2	225
Space	11h	SSC	226
Test Unit Ready	00h	SSC	228
Verify	13h	SSC-2	229
Write	0Ah	SSC	233
Write T10 PI	9Ah	SSC-5	237
Write Buffer	3Bh	SPC-2	239
Write Filemarks	10h	SSC	241

Implementation Requirements

The initiator sends commands to the target using Command Descriptor Blocks (CDBs). The CDBs contain a format that includes:

- Operation code
- Command parameters
- Control byte

For some commands, a list of parameters accompanies the request during subsequent FCP_DATA Information Units.

For all commands, if there is an invalid parameter in the Command Descriptor Block, then the device terminates the command without altering the medium or executing the command.

Notes:

- The CDB Field in Byte 1, Bits 7-5, which was the LUN Field is now reserved. The drive will ignore this field.
- RSVD indicates that “bit” is reserved.

Command Descriptor Block

Initiators use three types of CDBs to communicate commands to the targets:

- 6–Byte commands (TABLE 3-2)
- 10–Byte commands (TABLE 3-3)
- 12-Byte commands (TABLE 3-4)
- 16-Byte commands (TABLE 3-5)

The first byte in the command descriptor block contains an operation code.

TABLE 3-2 6-Byte Command Descriptor Block

Byte	Bit 7	6	5	4	3	2	1	0
0	Operation Code							
1	Reserved			Command Parameters				
2 thru 4	(MSB) Command Parameters (LSB)							
5	Control Byte							

TABLE 3-3 10-Byte Command Descriptor Block

Byte	Bit 7	6	5	4	3	2	1	0
0	Operation Code							
1	Reserved			Command Parameters				
2 thru 8	(MSB) Command Parameters (LSB)							
9	Control Byte							

TABLE 3-4 12-Byte Command Descriptor Block

Byte	Bit 7	6	5	4	3	2	1	0
0	Operation Code							
1	Reserved			Command Parameters				
2 thru 9	(MSB) Command Parameters (LSB)							
10	Reserved							

TABLE 3-4 12-Byte Command Descriptor Block (Continued)

Byte	Bit 7	6	5	4	3	2	1	0
11	Control Byte							

TABLE 3-5 16-Byte Command Descriptor Block

Byte	Bit 7	6	5	4	3	2	1	0
0	Operation Code							
1	Reserved				Command Parameters			
2 thru 13	(MSB) Command Parameters (LSB)							
14	Reserved							
15	Control Byte							

Control Byte

The control byte is the last byte of every Command Descriptor Block and has the following structure:

TABLE 3-6 Control Byte

Byte	Bit							
	7	6	5	4	3	2	1	0
5/9/11/15	Vendor-specific		Reserved				Flag	Link

Parameter	Value
Vendor-specific	These bits provide specific information about the device (shall be zero).
Flag bit	The flag bit causes an interrupt in the initiator between linked commands allowing the device to respond with Intermediate status (shall be zero).
Link bit	The link bit allows the initiator to “link” or continue I/O process and allows devices that support command linking to indicate to the initiator the command was accepted by returning Intermediate status to the initiator (shall be zero).

Erase Command

The Erase command erases the remainder of the tape starting at the current, logical position. Any buffered write data and filemarks are written on the tape *before* the erase operation starts.

> **Note –** At the completion of the Erase command, the tape is positioned at the physical end-of-volume (PEOV) if the data security erase (DSE) configuration option is set to full.

TABLE 3-7 Erase Command

Byte	Bit 7	6	5	4	3	2	1	0
0	Operation Code (19h)							
1	Reserved						Immed	Long
2 thru 4	(MSB) Reserved (LSB)							
5	Control Byte							

Parameter	Value
Immed: Immediate	0 = Return status when erase is completed
	1 = Return status when erase is started
Long: Long	0 = Ignored, no erase performed
	1 = Erase to the physical end-of-volume starting at the current logical position.

> **Note –** Issuing a Test Unit Ready command after an Erase command with the Immed bit set returns Busy status until the erase is complete.

Generate Recommended Access Order Command

The Generate Recommended Access Order (GRAO) command generates a recommended access order for the User Data Segments that are sent by the command as parameter data. The GRAO command is defined by an operation code and Service Action. The GRAO parameter list is processed before status for the command is returned. After the GRAO command completes the Receive Recommended Access Order (RRAO) command can be used to receive the results in the form of a Recommended Access Order (RAO) list.

TABLE 3-8 Generate Recommended Access Order Command

Byte	Bit 7	6	5	4	3	2	1	0
0	Operation Code(A4H)							
1	Reserved			Service Action (11h)				
2	Reserved					RAO Process		
3	Reserved					UDS_Type		
4 thru 5	Reserved							
6 thru 9	(MSB) Parameter List Length (LSB)							
10	Reserved							
11	Control Byte							

Parameter	Value
RAO Process: Method used to generate RAO list	000b = List of user data segments not reordered, estimated locate times from current position to first logical block 001b = List of user data segments not reordered, estimated locate times from current position to first logical block and then from last logical block in previous user data segment to first logical object in this user data segment. 010b = List of user data segments is reordered into the recommended access order, estimated locate times from current position to first logical block in the reordered list and then from last logical block in previous user data segment to first logical object of this user data segment. 000b = List of user data segments not reordered, estimated locate times from beginning of partition 0 to the position to first logical block in each user data segment.

Parameter	Value
UDS Type: Format of the User Data Segment descriptor to be used in the resulting RAO list	000b = User Data Segment
Parameter List Length: Length in bytes of GRAO list transferred from initiator.	00000000h = Clear RAO list

TABLE 3-9 Generate Recommended Access Order Parameter List

Byte	Bit 7	6	5	4	3	2	1	0
0 thru 3	Reserved							
4 thru 7	(MSB) Additional Data (n-7) (LSB)							
User Data Segment Descriptor List								
x	(MSB) User Data Segment descriptor (first) (LSB)							
...								
y thru n	(MSB) User Data Segment descriptor (last) (LSB)							

UDS Descriptor List Length: Number of bytes to follow

User Data Segment Descriptor List: List of UDS's to be processed

TABLE 3-10 GRAO - User Data Segment descriptor

Byte	Bit 7	6	5	4	3	2	1	0
0 thru 1	(MSB) Descriptor Length (1Eh) (LSB)							
2	Reserved							
3	Reserved							
4	Reserved							
5 thru 14	(MSB) UDS Name (LSB)							
15	Partition Number							
16 thru 23	(MSB) Beginning Logical Object Identifier (LSB)							
24 thru 31	(MSB) Ending Logical Object Identifier (LSB)							

Descriptor Length: number of bytes to follow

UDS Name: Host specified name for User Data Segment

Partition Number: Number of partition in which User Data Segment is located.

Beginning Logical Object Identifier: Logical object identifier of first logical object in User Data Segment

Ending Logical Object Identifier: Logical object identifier of last logical object in User Data Segment

Format Medium Command

The Format Medium command is used partition the medium. The command must be issued only after positioning the tape to beginning of partition 0.

TABLE 3-11 Format Medium Command

<table>
<tr><th rowspan="2">Byte</th><th colspan="8">Bit</th></tr>
<tr><th>7</th><th>6</th><th>5</th><th>4</th><th>3</th><th>2</th><th>1</th><th>0</th></tr>
<tr><td>0</td><td colspan="8">Operation Code (04h)</td></tr>
<tr><td>1</td><td colspan="6">Reserved</td><td>Verify</td><td>Immed</td></tr>
<tr><td>2</td><td colspan="4">Reserved</td><td colspan="4">Format</td></tr>
<tr><td>3
thru
4</td><td colspan="8">Transfer Length</td></tr>
<tr><td>5</td><td colspan="8">Control Byte</td></tr>
</table>

Parameter	Value
Verify: Verify that format was successful	0 = Not supported
Immed: Immediate	0 = Return status after format completes
Format	0h = Use default partition (non partitioned tape)
	2h = Partition tape according to mode page 11h
Transfer Length	0000h = No data is transferred for format medium command

Inquiry Command

The Inquiry command returns information about the type and capabilities of a SCSI device.

TABLE 3-12 Inquiry Command

Byte	Bit 7	6	5	4	3	2	1	0
0	Operation Code (12h)							
1	Reserved						CmdDt	EVPD
2	Page Code							
3 thru 4	(MSB) Allocation Length							(LSB)
5	Control Byte							

Parameter	Value
CmdDt: Command support Data	0 = Do not return command support data
EVPD: Enable Vital Product Data	0 = Return normal inquiry data 1 = Return Vital Product Data
Page Code	EVPD page to return
Allocation Length	Specifies the maximum length of inquiry data to return

Notes:

- The Inquiry command returns 74 bytes of data. If the allocation length is less than 74 bytes, the data is truncated.
- The Inquiry command returns check condition status only when the requested data cannot be returned. This command will not clear any pending unit attention conditions.

Inquiry Data Format

The Inquiry data format contains 74 bytes shown in TABLE 3-13.

TABLE 3-13 Inquiry Data Format

Byte	Bit 7	6	5	4	3	2	1	0
0	Peripheral Qualifier			Peripheral Device Type				
1	RMB	Reserved						
2	ECMA Version							
3	AERC	RSVD	NormACA	HiSup	Response Data Format			
4	Additional Length (n - 4)							
5	SCCS	ACC	TPGS		3PC	Reserved		Protect
6	BQue	EncServ	VS	MultiP	MChngr	Reserved		
7	RelAdr	Reserved			Linked	RSVD	CmdQue	VS
8 thru 15	(MSB) Vendor Identification (LSB)							
16 thru 31	(MSB) Product Identification (LSB)							
32 thru 39	(MSB) Product Revision Level (LSB)							
40 thru 53	(MSB) Vendor Specific (LSB)							
54	Key Management (KM)							
55	Reserved			Encrypt	LibAtt	VolSafe	DCMP	CSL
56 thru 57	(MSB) Reserved (LSB)							
58 thru 73	(MSB) Version Descriptor 1 to 8 (2 bytes each) (LSB)							

Parameter	Value
Peripheral Qualifier	000b = Peripheral device is connected to this logical unit 011b = Not capable of supporting a device on this logical unit
Peripheral Device Type	01h = Device is a sequential access device (tape drive) 1Fh = Device does not exist or is offline
RMB: Removable Medium Bit	1 = Medium is removable
ECMA Version European Computer Manufacturers Association	05h = Complies with ANSI INCITS 408-2005 (SPC-3)
AERC: Asynchronous Event Reporting Capability	0 = Not supported
NormACA: Normal Auto Contingent Allegiance	0 = Not supported
HiSup: Hierarchical Support	0 = Not supported
Response Data Format	02 = Inquiry data is in ANSI SPC–2 format
Additional Length	45h = 69 additional bytes of data follows
SCCS: SCSI Controller Command Support	0 = Not supported
ACC: Access Controls Coordinator	0 = Not supported
TPGS: Target Port Group Support	01b = Supports only implicit asymmetric logical unit access
3PC: Third-Party Copy	0 = Not supported
Protect	0 = The logical unit does not support protection information. 1 = The logical unit supports protection information.
BQue: Basic Queuing	0 = Not Supported
EncServ: Enclosure Services	0 = Not supported
VS: Vendor Specific	0 = Not supported
MultiP: Multi-Port	1 = Supports two ports
MChngr: Medium Changer	0 = Not supported
RelAdr: Relative Address	0 = Not supported
Linked: Linked commands	0 = Not supported
CmdQue: Command Queuing	0 = Not supported
Vendor Identification	STK = StorageTek, Sun Microsystems (ASCII)
Product Identification: Device type in ASCII	T10000A = Drive is a T10000A T10000B = Drive is a T10000B T10000C = Drive is a T10000C T10000D = Drive is a T10000D

Parameter	Value
Product Revision: 8 byte ASCII field	For example: 4XX1YY where XX=02 and YY=03 (402103) indicates: • Model number for T10000D = 4, • Major Revision = 02, • Released code = 1, • Minor release = 03 These 6 characters will be left justified with blank fill as needed. This field will change with each drive firmware release.
VS: Vendor Specific	Vendor Specific 0 = Not supported
Key Management (KM)	0 = None 1 = Key Management Station (KMS) Version 1 2 = Key Management System (KMS) Version 2 4 = Data Path Key Management (DPKM) Spin/Spout
Encrypt: Encryption	Encryption: 0 = Not encrypting drive 1 = Encrypting drive
LibAtt: Library Attach	Library Attachment: 0 = Drive is not attached to a library 1 = Drive is attached to a library
VolSafe: VolSafe available	1 = VolSafe enabled A Sun StorageTek write once, read many (WORM) technology to designated tape cartridges.
DCMP: Data Compression	0 = Data compression is disabled 1 = Data compression is enabled
CSL: Cartridge Scratch Loader installed	0 = CSL is not installed
Version Descriptor	Standards supported by this device: • 0000h = Empty • 0077h = SAM-3_ANSI_INCITS.402:2005 • 0314h = SPC-3_ANSI_INCITS.408:2005 • 0403h = SSC-3 T10/1611-D Revision 04a • 0A11h = FCP-3_ANSI_INCITS.416:2006

Vital Product Data Pages

There are three vital product data pages that contain specific information:

00h = Supported vital product data pages (TABLE 3-14)
80h = Device serial number page (TABLE 3-15)
83h = Device identification page (TABLE 3-16)
85h = Management Network Address page (TABLE 3-17)
B0h = Sequential Access Device Capabilities page (TABLE 3-18)

TABLE 3-14 Supported Vital Product Data Pages

Byte	Bit 7	6	5	4	3	2	1	0
0	Peripheral Qualifier			Peripheral Device Type				
1	Page Code (00h)							
2	Reserved							
3	Page Length (05h)							
4	Supported VDE Pages (00h)							
5	Device Serial Number Page (80h)							
6	Device Identification Page (83h)							
7	Management Network Addresses Page (85h)							
8	Sequential Access Device Capabilities page (B0h)							

Vital Product Data (VPD)
Page Code = 00h returns a list of the supported VPD pages.

TABLE 3-15 Device Serial Number Page

Byte	Bit 7	6	5	4	3	2	1	0
0	Peripheral Qualifier			Peripheral Device Type				
1	Page Code (80h)							
2	Reserved							
3	Page Length (0Ch)							
4 thru 15	(MSB) Serial Number (ASCII) (LSB)							

Page Code = 80h returns the tape drive serial number in ASCII.

TABLE 3-16 Device Identification Page

Byte	Bit 7	6	5	4	3	2	1	0
0	Peripheral Qualifier			Peripheral Device Type				
1	Page Code (83h)							
2	Reserved							
3	Page Length (28h)							
Node Name Identifier								
4	Reserved				Code Set (1)			
5	Reserved		Association (0)		Identifier Type (3)			
6	Reserved							
7	Identifier Length (08h)							
8 thru 15	(MSB) Node Identifier (binary) (LSB)							
Port Name Identifier								
16	Reserved				Code Set (1)			
17	Reserved		Association (1)		Identifier Type (3)			
18	Reserved							
19	Identifier Length (08h)							
20 thru 27	(MSB) Port Identifier (binary) (LSB)							
Port Number Identifier								
28	Reserved				Code Set (1)			
29	Reserved		Association (1)		Identifier Type (4)			
30	Reserved							
31	Identifier Length (04h)							
32 thru 35	(MSB) Port Identifier (binary) (LSB)							
Target Port Group								
36	Reserved				Code Set (1)			
37	Reserved		Association (1)		Identifier Type (5)			
38	Reserved							
39	Identifier Length (04h)							

TABLE 3-16 Device Identification Page (Continued)

Byte	Bit 7	6	5	4	3	2	1	0
40 thru 41	(MSB) Target Port Group Identifier (binary) (LSB)							

Parameter	Value
Page Code	83h returns four identifying numbers. • World Wide Name (WWN) for the tape drive • WWN for the port that accepted the Inquiry command • Port Number (1 or 2) for that port • Target Port Group Descriptor
Code Set	1h = Identifier field contains binary values
Association	00b = Identifier is for the device 01b = Identifier is for a port
Identifier Type	3h = Identifier field contains a 64 bit IEEE registered format address, also known as a World Wide Name. 4h = Identifier field contains a 4 byte port number
Identifier Length	Length in bytes of the WWN or Port Number Identifier
Node Identifier	Contains the device WWN
Port Identifier	Contains WWN for the current port
Port Number Number for the current port	01h = Command accepted by device port A 02h = Command accepted by device port B
Target Port Group	Contains the primary Target Port Group

TABLE 3-17 Management Network Addresses Page

<table>
<tr><th rowspan="2">Byte</th><th colspan="8">Bit</th></tr>
<tr><th>7</th><th>6</th><th>5</th><th>4</th><th>3</th><th>2</th><th>1</th><th>0</th></tr>
<tr><td>0</td><td colspan="3">Peripheral Qualifier (000b)</td><td colspan="5">Peripheral Device Type (01h)</td></tr>
<tr><td>1</td><td colspan="8">Page Code (85h)</td></tr>
<tr><td>2</td><td colspan="8" rowspan="2">Page Length (1Eh)</td></tr>
<tr><td>3</td></tr>
<tr><td>4</td><td>RSVD</td><td colspan="2">Association</td><td colspan="5">Service Type</td></tr>
<tr><td>5</td><td colspan="8">Reserved</td></tr>
<tr><td>6
thru
7</td><td colspan="8">(MSB)
Network Address Length
(LSB)</td></tr>
<tr><td>8
thru
33</td><td colspan="8">(MSB)
Network Address
(LSB)</td></tr>
</table>

Parameter	Value
Peripheral Qualifier	000b = Peripheral Device is connected to this Logical Unit
Peripheral Device Type	01h = Device is a sequential-access device (tape drive)
Association	2h = Network address is associated with this SCSI target device
Service Type	00h = Service type is unspecified
Network Address	For example, TELNET://123.345.123.123/
The URL of the accessing drive management port	Field is an ASCII string terminated with one or more null (00h) characters. If management port is not connected to an active network, field will be filled with 00h.

TABLE 3-18 Sequential Access Device Capabilities Page

Byte	Bit 7	6	5	4	3	2	1	0
0	Peripheral Qualifier (000b)			Peripheral Device Type (01h)				
1	Page Code (B0h)							
2 thru 3	Page Length (02h)							
4	Reserved							WORM
5	Reserved							

Parameter	Value
Peripheral Qualifier	000b = Peripheral Device is connected to this Logical Unit
Peripheral Device Type	01h = Device is a sequential-access device (tape drive)
WORM	1 = Device supports write once, read many (WORM) modes of operation (VolSafe)

Load Display Command

The Load Display command (vendor specific) displays ASCII messages on the virtual operator panel for that device. This command transfers 17 bytes of data to the display. The data transferred contains one byte of display control data and two, eight-byte ASCII messages.

TABLE 3-19 Load Display Command

Byte	Bit 7	6	5	4	3	2	1	0
0	Operation Code (06h)							
1	Reserved							
2	Reserved							
3	Reserved							
4	Transfer Length (11h)							
5	Control Byte							

Load Display Data Format

TABLE 3-20 Load Display Data Bytes

Byte	Bit 7	6	5	4	3	2	1	0
0	Overlay			Alt	Blink	L/H	Reserved	
1 thru 8	(MSB) (ASCII) Message 1 (LSB)							
9 thru 16	(MSB) (ASCII) Message 2 (LSB)							

Notes:

- Messages in bytes 1–8 and 9–16 use the ASCII printable character set.
- Non-printable characters are displayed as blanks.
- The format control byte controls the way the device displays the remaining 16 bytes.

Parameter	Value
Overlay: New message overlay	000 = Display the message in bytes 1–8 or 9–16 until the next command that initiates tape motion or the next Load Display Command.
	001 = Maintain the message in bytes 1–8 until the cartridge is unloaded. If the drive does not contain a cartridge when the Load Display Command is received, the message will not be changed.
	010 = Maintain the message in bytes 1–8 and turn on the Attention light until the drive is next loaded. If the drive is loaded when the Load Display Command is received, the command is ignored.
	011 = Physically access the tape drive without changing the message display.
	111 = Display the message in bytes 1–8 until the tape drive is unloaded, then display the message in bytes 9–16 until the tape drive is loaded again. If the tape drive is not loaded when the Load Display Command is issued, only the message in bytes 9–16 are displayed.
Alt: Alternate message	0 = The device displays only the message specified in bit 2.
	1 = The device alternately displays both messages specified in bytes 1–8 and 9–16. Each message is displayed for about two seconds, with 0.5 seconds between messages. Bits 2 and 3 are ignored.
Blink: Blinking message	0 = The message specified by the setting of bit 2 does not blink.
	1 = The message specified by the setting of bit 2 flashes on and off.
L/H: Display low/high message	0 = Display message specified in bytes 1–8.
	1 = Display message specified in bytes 9–16.

Load/Unload Command

The Load/Unload command loads or unloads tape from the device. Any buffered write data and filemarks are written on the tape *before* an unload starts.

Caution – If the drive is in Buffered Mode and a previous command terminated with Check Condition status (such as buffered data unwritten to tape and the condition was not cleared or otherwise recovered), the drive will discard any unwritten buffered data and filemarks before this operation starts.

TABLE 3-21 Load/Unload Command

Byte	Bit 7	6	5	4	3	2	1	0
0	Operation Code (1Bh)							
1	Reserved							Immed
2 thru 3	(MSB) Reserved (LSB)							
4	Reserved				Hold	EOT	Reten	Load
5	Control Byte							

Parameter	Value
Immed: Immediate	0 = Return status when load or unload is complete 1 = Return status when load or unload is started
Hold	Not supported 0 = Normal load/unload
EOT: End-Of-Tape	0 = Tape is unloaded from BOT
Reten: Retention	0 = Do not retention the tape 1 = Retention tape (ignored)
Load	0 = Unload the tape 1 = Load the tape

Notes:

- After a load or unload operation with the Immediate bit set, a Test Unit Ready command returns Busy status while the Load/Unload command is still in progress.
- After a successful load operation, Good status is returned. The next command returns a sense key of unit attention.
- If a Load command is issued when a tape is already loaded, the Load command is ignored.
- If the drive is installed in a library, a load command to an unloaded drive is rejected.

- When the drive needs cleaning, an unload will return Check Condition status with a Sense Key of 0h and an ASC/ASCQ of 0017h indicating the tape drive requires cleaning.

Locate Command

The Locate command requests the tape drive to position the tape to a specified block address. Any buffered write data and filemarks are written on the tape *before* this operation starts.

TABLE 3-22 Locate Command

Byte	Bit 7	6	5	4	3	2	1	0
0	Operation Code (2Bh)							
1	Reserved					BT	CP	Immed
2	Reserved							
3 thru 6	(MSB) Block Address (LSB)							
7	Reserved							
8	Partition							
9	Control Byte							

Parameter	Value
BT: Block Address Type	0 = SCSI logical block address 1 = Vendor - specific (ignored)
CP: Change Partition	0 = Ignore partition field
Immed: Immediate	0 = Return status when locate is complete 1 = Return status when locate is started
Block Address	Logical block address position
Partition	00h = Default partition

Note – After a Locate command with the Immediate bit set. A Test Unit Ready command returns Busy status while the operation is in progress.

Locate(10) Command

The locate(10) command is used to position the medium to the specified partition and logical block address.

TABLE 3-23 Locate(10) Command

Byte	Bit 7	6	5	4	3	2	1	0
0	Operation Code (2Bh)							
1	Reserved					BT	CP	Immed
2	Reserved							
3 thru 6	(MSB) Block Address (LSB)							
7	Reserved							
8	Partition							
9	Control Byte							

Parameter	Value
BT: Block Address Type	0 = SCSI logical block address 1 = Vendor - specific (ignored)
CP: Change Partition	0 = Ignore partition field 1 = Change partition
Immed: Immediate	0 = Return status when locate is complete 1 = Return status when locate is started
Block Address	Logical block address position
Partition	Partition number

Locate(16) Command

The Locate(16) command is used to position the medium to the specified partition and logical block identifier.

TABLE 3-24 Locate(16) Command

Byte	Bit							
	7	6	5	4	3	2	1	0
0	Operation Code (92h)							
1	Reserved			DEST_TYPE		BT	CP	Immed
2	Reserved							
3 thru 6	(MSB) Block Address (LSB)							
7	Reserved							
8	Partition							
9	Control Byte							

Parameter	Value
DEST_TYPE: Logical position upon successful completion	00b == Logical object identifier, BOP side
CP: Change Partition	0 = Ignore partition field 1 = Change partition
Immed: Immediate	0 = Return status when locate is complete 1 = Return status when locate is started
BAM: Block address mode	0 = Process command as an implicit address command
Partition	Partition number
Logical Identifier	Logical block address position

Log Select Command

The initiator uses the Log Select command to manage information about the device or media.

TABLE 3-25 Log Select Command

Byte	Bit 7	6	5	4	3	2	1	0
0	Operation Code (4Ch)							
1	Reserved						PCR	SP
2	PC		Reserved					
3 thru 6	(MSB) Reserved (LSB)							
7 thru 8	(MSB) Parameter List (LSB)							
9	Control Byte							

Parameter	Value
PCR: Parameter Code Reset	0 = No operation performed 1 = Reset all parameters to default values
SP: Save Parameters	0 = Not supported
PC: Page Control	11b = Set Default Cumulative Values
Parameter List	Length in bytes of log parameter data to be transferred to the tape drive 00h = No parameter data

Notes:

- Setting the parameter code reset bit to one, clears all cumulative statistics.
- If the parameter code reset (PCR) bit is set to 0, this command is ignored and no values are reset.
- If the SP bit and the parameter list length field are not both 0, this command is rejected.

Log Sense Command

The Log Sense command returns device statistical data to the host.

TABLE 3-26 Log Sense Command

Byte	Bit 7	6	5	4	3	2	1	0
0	Operation Code (4Dh)							
1	Reserved						PPC	SP
2	PC		Page Code					
3	Subpage Code							
4	(MSB) Reserved (LSB)							
5 thru 6	(MSB) Parameter Pointer (LSB)							
7 thru 8	(MSB) Allocation Length (LSB)							
9	Control Byte							

Parameter	Value
PPC: Parameter Pointer Control	0 = Send all log parameters for the specified log page 1 = Vendor specific (ignored)
SP: Save Parameters	0 = Not supported
PC: Page Control	00b = Current Threshold Values 01b = Current Cumulative Values 10b = Default Threshold Values 11b = Default Cumulative Values
Page Code: Log page to return	00h = Supported log pages 02h = Write error counter page 03h = Read error counter page 06h = Non-medium error page 0Ch = Sequential access device page 2Eh = Tape alert page 3Ah = Vendor unique drive statistics page (T10000A or T10000B only) 3Bh = Vendor unique port statistics page 3Ch = Vendor unique drive statistics page (T10000C only) 3Dh = Vendor unique drive statistics page (T10000D only)
Parameter Pointer	Return data starting at this parameter code
Allocation Length	Maximum length of parameter data to transfer

Log Sense Page Format

Each log page begins with a four–byte page header followed by variable–length log parameters.

TABLE 3-27 Log Sense Page Format

Byte	Bit 7	6	5	4	3	2	1	0
0	Reserved		Page Code					
1	Reserved							
2 thru 3	(MSB) Page Length (n-3) (LSB)							
Log Parameter(s)								
4	Log Parameter (First)							
x + 3	(Length = x)							
	. . .							
n-y+1	Log Parameter (Last)							
n	(Length = y)							

Note – The page length reflects the absolute length of the page, and is not adjusted because of the allocation length or the parameter pointer fields.

Log Sense Parameter Format

TABLE 3-28 Log Sense Parameter Format

Byte	Bit 7	6	5	4	3	2	1	0
0 thru 1	(MSB) Parameter Code (LSB)							
2	DU	DS	TSD	ETC	TMC		RSVD	LP
3	Parameter Length (n-3)							
4 thru n	(MSB) Parameter Value (LSB)							

Parameter	Value
Parameter Code	Identifies the log parameter being transferred
DU: Disable Update	0 = Drive updates log parameter value
DS: Disable Save	1 = saving the log is not supported
TSD: Target Save Disable	0 = Target provides a target defined method for saving log parameters 1 = Target does not provide a target defined method for saving the log parameters
ETC: Enable Threshold Comparison	0 = Comparison is not performed 1 = Comparison is performed
TMC: Threshold Met Criteria	00b = Every update 01b = Cumulative value equal threshold value 10b = Cumulative value not equal threshold value 11b = Cumulative value greater than threshold value
LP: List Parameter	0 = Log parameter is a data counter.

Log Sense Supported Pages

The Log Sense supported pages report which pages the tape drive supports. TABLE 3-29 lists pages for the T10000A or T10000B tape drives while TABLE 3-30 on page 67 lists the pages for the T10000C or T10000D tape drives.

TABLE 3-29 Log Sense Supported Pages (T10000A or T10000B only)

Byte	Bit 7	6	5	4	3	2	1	0
0	Reserved		Page Code (00h)					
1	Reserved							
2 thru 3	(MSB) Page Length (08h) (LSB)							
4	Supported Log Pages (00h)							
5	Write Error Counter Page (02h)							
6	Read Error Counter Page (03h)							
7	Non-medium Error Page (06h)							
8	Sequential Access Device Page (0Ch)							
9	Tape Alert Page (2Eh)							
10	Vendor Unique Drive Statistics Page (3Ah)							
11	Vendor Unique Port Statistics Page (3Bh)							

TABLE 3-30 Log Sense Supported Pages (T10000C only)

Byte	Bit 7	6	5	4	3	2	1	0
0	Reserved		Page Code (00h)					
1	Reserved							
2 thru 3	(MSB) Page Length (08h) (LSB)							
4	Supported Log Pages (00h)							
5	Write Error Counter Page (02h)							
6	Read Error Counter Page (03h)							
7	Non-medium Error Page (06h)							
8	Sequential Access Device Page (0Ch)							
9	Tape Alert Page (2Eh)							
10	Vendor Unique Port Statistics Page (3Bh)							
11	Vendor Unique Drive Statistics Page (3Ch)							

TABLE 3-31 Log Sense Supported Pages (T10000D only)

Byte	Bit 7	6	5	4	3	2	1	0
0	Reserved		Page Code (00h)					
1	Reserved							
2 thru 3	(MSB) Page Length (08h) (LSB)							
4	Supported Log Pages (00h)							
5	Write Error Counter Page (02h)							
6	Read Error Counter Page (03h)							
7	Non-medium Error Page (06h)							
8	Sequential Access Device Page (0Ch)							
9	Tape Alert Page (2Eh)							
10	Vendor Unique Port Statistics Page (3Bh)							
11	Vendor Unique Drive Statistics Page (3Dh)							

Log Page 3C Subpage 01

The Log Page 3C Subpage 01 is used to check the status of a completed Media Validation on a T10000C Tape Drive.

TABLE 3-32 Data Returned for Log Page 3C Subpage 01

Parameter Code	Description	Size in bytes
0101h	Percent Complete	4
0102h	Reserved	4
0103h	HLU ID Completed	8
0104h	Partition Completed	4
0105h	Perm	4
0106h	Elapsed Time	4
0107h	Start HLU ID	8
0108h	Start Partition	4

Log page 3D Subpage 01

The Log Page 3D Subpage 01 is used to check the status of a completed Media Validation on a T10000D Tape Drive.

TABLE 3-33 Data Returned for Log Page 3D Subpage 01

Parameter Code	Description	Size in bytes
0101h	Percent Complete	4
0102h	Reserved	4
0103h	HLU ID Completed	8
0104h	Partition Completed	4
0105h	Perm	4
0106h	Elapsed Time	4
0107h	Start HLU ID	8
0108h	Start Partition	4

Write Error Counter Page

The Write Error Counter page (02h) reports write statistical errors. Each parameter is a counter incriminated by the target each time a corresponding event occurs.

TABLE 3-34 Write Error Counter Page Codes

Parameter Code	Description	Length (bytes)	Default Threshold
0000h	Errors corrected without substantial delays	4	FFFFFFFF
0001h	Errors corrected with possible delays	4	FFFFFFFF
0002h	Total number of re-writes	4	FFFFFFFF
0003h	Number of records with a recovered data check while writing	4	FFFFFFFF
0004h	Always 0	4	FFFFFFFF
0005h	Number of non–compressed bytes transferred from the initiator	8	FFFFFFFF FFFFFFFF
0006h	Total number of uncorrected errors	4	FFFFFFFF

Read Error Counter Page

The Read Error Counter page (03h) reports statistical errors for read operations. Each parameter is a counter that the target increments when an event occurs.

TABLE 3-35 Read Error Counter Page Codes

Parameter Code	Description	Length (bytes)	Default Threshold
0000h	Errors corrected without substantial delays	4	FFFFFFFF
0001h	Errors corrected with possible delays	4	FFFFFFFF
0002h	Total number of re-reads	4	FFFFFFFF
0003h	Number of records with a recovered data check while reading	4	FFFFFFFF
0004h	Number of times a record was retried before recovery either passed or failed	4	FFFFFFFF
0005h	Number of non–compressed bytes transferred to the initiator	8	FFFFFFFF FFFFFFFF
0006h	Total number of uncorrected errors	4	FFFFFFFF

Non-Medium Error Page

The Non-Medium Error page (06h) reports a count of recoverable errors other than read/write failures.

TABLE 3-36 Non-Medium Error Page Codes

Parameter Code	Description	Length (bytes)	Default Threshold
0000h	Non-medium error count	4	FFFFFFFF

Sequential Access Device Page

The Sequential Access Device page (0Ch) returns counts of data bytes transferred to and from tape and information about cleaning in binary format.

TABLE 3-37 Sequential Access Device Page Codes

Parameter Code	Description	Length (bytes)	Default Threshold
0000h	Number of bytes received from the initiator (write command)	8	FFFFFFFF FFFFFFFF
0001h	Number of data bytes written on tape	8	FFFFFFFF FFFFFFFF
0002h	Number of bytes read from tape	8	FFFFFFFF FFFFFFFF
0003h	Number of bytes read by the initiator	8	FFFFFFFF FFFFFFFF
0100h	Cleaning 000 = No cleaning required 001 = Cleaning required	4	N/A
8000h	Number of 4k bytes left on tape from the current position	4	N/A

TapeAlert Page

The TapeAlert Log Sense page (2Eh) is read from a tape drive at the following times, as a minimum:

- At the beginning of a write/read job, after the media is loaded.
- Immediately after a fatal error during the write/read job.
- At the end of each tape when the write/read job spans multiple tapes.
- At the end of a write/read job, when the tape has been unloaded.

Each flag will be cleared to zero in the following circumstances:

- At drive power on.
- When the TapeAlert Log page is read.
- When specified corrective action has been taken (such as using a cleaning cartridge).
- On a reset.

Note – The entire TapeAlert page should be read to obtain all the information.

When a flag is cleared by reading the TapeAlert page, a flag cannot be set again until the error condition is removed (for example, the specific corrective action has been taken).

A Log Select Reset for the TapeAlert page does not reset the TapeAlert flags. It is rejected with Illegal Request.

TapeAlert Flags

TABLE 3-38 TapeAlert Flags

Code	Flag Name	Description	Length (bytes)
0001h	Read Warning	Drive has difficulty reading	1
0002h	Write Warning	Drive has difficulty writing	1
0003h	Hard Error	Write or read hard error has occurred (flags 4, 5, 6)	1
0004h	Media	Unrecoverable read, write, or positioning error caused by faulty media	1
0005h	Read Failure	Hard read error, hardware or media	1
0006h	Write Failure	Hard write error, hardware or media	1
0007h	Media Life	Media has exceeded the life pass count	1
0008h	Not Data Grade	Not supported	1
0009h	Write Protect	Write command was issued to a write-protected tape	1
000Ah	No Removal	A manual unload or Unload command was issued while the drive was in prevent removal state – not supported	1
000Bh	Cleaning Media	The tape in the drive is a cleaning cartridge	1
000Ch	Unsupported Format	Unrecognized format	1
000Dh	Recoverable Snapped Tape	Snapped tape – not supported	1
000Eh	Unrecoverable Snapped Tape	Not supported	1
000Fh	Memory Chip in Cartridge Failure	The RFID chip cannot be read or written to.	1
0010h	Forced Eject	A manual eject was performed before a reposition to BOT was commanded. Not supported	1
0011h	Read Only Format	Not supported	1
0012h	Tape Directory Corrupted	MIR corrupted	1
0013h	Nearing Media Life	The tape is nearing the end of its calculated life	1
0014h	Clean Now	The drive has determined it needs cleaning.	1
0015h	Clean Periodic	Cleaning counter has reached threshold, cleaning LED is on	1
0016h	Expired Cleaning Media	The last cleaning cartridge inserted was used up – not supported	1
0017h	Invalid Cleaning Media	Not supported	1
0018h	Retention Requested	Not supported	1
0019h	Dual port interface error	Not supported	1

TABLE 3-38 TapeAlert Flags (Continued)

Code	Flag Name	Description	Length (bytes)
001Ah	Cooling fan failure	Not supported	1
001Bh	Power supply failure	Not supported	1
001Ch	Power consumption	Not supported	1
001Dh	Drive Maintenance	Preventive maintenance of the drive is required	1
001Eh	Hardware A	Drive has a hardware fault	1
001Fh	Hardware B	Hardware not read/write related – not supported	1
0020h	Interface	Having problems with the interface, SCSI parity errors detected	1
0021h	Eject Media	Eject the media and retry, load failure not tape snap	1
0022h	Download Fail	Microcode update failed	1
0023h	Drive Humidity	Not supported	1
0024h	Drive Temperature	Temperature inside the tape drive is above specified range	1
0025h	Drive Voltage	Not supported	1
0026h	Predictive Failure	A hardware failure of the drive is predicted	1
0027h	Diagnostics Required	Dump available	1
0028h thru 002Eh	Reserved for CSL		
002Fh thru 0031h	Reserved		
0032h	Lost Statistics	Media statistics lost some time in the past.	1
0033h	Tape Directory Invalid at Unload	The tape directory on the tape cartridge just unloaded has been corrupted.	1
0034h	Tape System Area Write Fail	The tape just unloaded could not write its system area successfully.	1
0035h	Tape System Area Read Fail	The tape system area could not be read successfully at load time.	1
0036h	No Start of Data	The start of data could not be found on tape.	1
0037h	Loading failure	The operation has failed because the media could not be loaded and threaded.	1
0038h	Unrecoverable Unload failure	The operation has failed because the media could not be unloaded.	1
0039h	Automation Interface failure	Not supported.	1

TABLE 3-38 TapeAlert Flags (Continued)

Code	Flag Name	Description	Length (bytes)
003Ah	Firmware failure	The tape drive has reset itself due to a detected firmware fault.	1
003Bh thru 0040h	Reserved		

Tape Capacity Log Page

The Tape Capacity page (31h) reports the remaining capacity and the maximum capacity of the tape partitions. The values are in megabytes (1048576 bytes).

The T10000C returns parameters 0001h - 0004h. The T10000D returns parameters 0001h - 0014h.

TABLE 3-39 Tape Capacity Page Codes

Code	Description	Length (bytes)
0001h	Partition 0 Remaining Capacity	4
0002h	Partition 1 Remaining Capacity	4
0003h	Partition 0 Maximum Capacity	4
0004h	Partition 1 Maximum Capacity	4
0005h	Partition 2 Remaining Capacity	4
0006h	Partition 3 Remaining Capacity	4
0007h	Partition 2 Maximum Capacity	4
0008h	Partition 3 Maximum Capacity	4
0009h	Partition 4 Remaining Capacity	4
000Ah	Partition 5 Remaining Capacity	4
000Bh	Partition 4 Maximum Capacity	4
000Ch	Partition 5 Maximum Capacity	4
000Dh	Partition 6 Remaining Capacity	4
000Eh	Partition 7 Remaining Capacity	4
000Fh	Partition 6 Maximum Capacity	4
0010h	Partition 7 Maximum Capacity	4
0011h	Partition 8 Remaining Capacity	4
0012h	Partition 9 Remaining Capacity	4
0013h	Partition 8 Maximum Capacity	4
0014h	Partition 9 Maximum Capacity	4

A tape partitioned using the partition sizes as specified for the T10000C in the mode select page 11h above will return maximum capacity values of 22E7h and 414FF5h for partitions 0 and 1 respectively. A non partitioned tape (only default partition 0) will return capacity values in parameters 0001h and 0003h.

Partition 0 Maximum Capacity non partitioned tape

T10000A tape = 000746A5h

T10000B tape = 000E8D4Ah

T10000C tape = 0048C273h

T10000D tape = 00746A52h

Vendor Unique Drive Statistics Page

The T10000A and T10000B Vendor Unique Drive Statistics page (3Ah) reports a variety of vendor unique drive statistics.

TABLE 3-40 T10000A and T10000B Vendor Drive Statistics Page Codes

Parameter Code	Description	Length (Bytes)	Default Threshold
0100h	Read forward data checks	4	FFFFFFFF
0101h	Write data checks	4	FFFFFFFF
0102h	Read data checks without hardware	4	FFFFFFFF
0103h	Write data checks without hardware	4	FFFFFFFF
0104h	Read recovery retry count	4	FFFFFFFF
0105h	Read transient conditions	4	FFFFFFFF
0106h	Write transient conditions	4	FFFFFFFF
0107h	Servo temporaries	4	FFFFFFFF
0108h	Servo transients	4	FFFFFFFF
0109h	Corrections 2t	4	FFFFFFFF
010Ah	Matrices with PW1 and PW2	4	FFFFFFFF
010Bh	Matrices with PWs	4	FFFFFFFF
010Ch	Progressive write for servo off track	4	FFFFFFFF
010Dh	Progressive write type 1	4	FFFFFFFF
010Eh	Progressive write type 2	4	FFFFFFFF
010Fh	Selected channel VR^2 bit insertions	4	FFFFFFFF
0110h	Matrix check diagnostic only	4	FFFFFFFF
0111h	Data check diagnostic only	4	FFFFFFFF
0112h	Write recovery retry count	4	FFFFFFFF
0200h	Read data request time-outs	4	FFFFFFFF
0201h	Write data request time-outs	4	FFFFFFFF
0202h	Data transfer errors	4	FFFFFFFF
0203h	Temporary drive errors	4	FFFFFFFF
0204h	Permanent errors logged	4	FFFFFFFF
0300h	Channel read bytes processed	8	FFFFFFFF FFFFFFFF

Notes:

- The device write byte count will include file marks and pad bytes. These additional bytes will not be included in the device read byte count.
- Parameters 0400 – 0402 will not be reset by a Log Select command.

TABLE 3-40 T10000A and T10000B Vendor Drive Statistics Page Codes (Continued)

Parameter Code	Description	Length (Bytes)	Default Threshold
0301h	Device read bytes processed (*see notes*)	8	FFFFFFFF FFFFFFFF
0302h	Channel write bytes processed	8	FFFFFFFF FFFFFFFF
0303h	Device write bytes processed (*see notes*)	8	FFFFFFFF FFFFFFFF
0304h	Channel read blocks processed	8	FFFFFFFF FFFFFFFF
0305h	Channel write blocks processed	8	FFFFFFFF FFFFFFFF
0306h	Device read blocks processed	8	FFFFFFFF FFFFFFFF
0307h	Device write blocks processed	8	FFFFFFFF FFFFFFFF
0308h	Read write servo position units	8	FFFFFFFF FFFFFFFF
0309h	High speed servo position units	8	FFFFFFFF FFFFFFFF
030Ah	Servo position units	8	FFFFFFFF FFFFFFFF
030Bh	Tape reposition cycles	4	FFFFFFFF
030Ch	Time spent writing	8	FFFFFFFF FFFFFFFF
030Dh	Time spent reading	8	FFFFFFFF FFFFFFFF
030Eh	Tape over under reposition cycles	4	FFFFFFFF
0310h	Time tape reloaded	8	FFFFFFFF FFFFFFFF
0311h	Time tape in motion for read write	8	FFFFFFFF FFFFFFFF
0312h	Time tape in motion for position	8	FFFFFFFF FFFFFFFF
0400h	Tape efficiency index (*see notes*)	4	FFFFFFFF
0401h	Read quality index (*see notes*)	4	FFFFFFFF

Notes:

- The device write byte count will include file marks and pad bytes. These additional bytes will not be included in the device read byte count.
- Parameters 0400 – 0402 will not be reset by a Log Select command.

TABLE 3-40 T10000A and T10000B Vendor Drive Statistics Page Codes (Continued)

Parameter Code	Description	Length (Bytes)	Default Threshold
0402h	RBC quality index (*see notes*)	4	FFFFFFFF
0403h	DIA detected error index	4	FFFFFFFF
0404h	Reserved	4	FFFFFFFF
0405h	Reserved	4	FFFFFFFF
1000h	Outer ECC multi symbol correction	48	all FF's
1100h	Servo general purpose counter head 0	16	all FF's
1101h	Servo general purpose counter head 1	16	all FF's
1200h	Servo vote out head 0	32	all FF's
1201h	Servo vote out head 1	32	all FF's
1202h	Servo no data available head 0	32	all FF's
1203h	Servo no data available head 1	32	all FF's
1310h	PES histogram head 0 A	128	all FF's
1311h	PES histogram head 0 B	128	all FF's
1320h	PES histogram head 1 A	128	all FF’s
1321h	PES histogram head 1 B	128	all FF’s
1400h	Old VR^2 blocks	128	all FF's
1401h	Low Viterbi metric 0	128	all FF's
1402h	Low Viterbi metric 1	128	all FF's
1403h	Low Viterbi metric 2	128	all FF's
1404h	Inner ECC correction	128	all FF's
1405h	Data valid	128	all FF's
1406h	Outer ECC correction	128	all FF's

Notes:

- The device write byte count will include file marks and pad bytes. These additional bytes will not be included in the device read byte count.
- Parameters 0400 – 0402 will not be reset by a Log Select command.

Vendor Unique Port Statistics Page

The Vendor Unique Port Statistics page (3Bh) reports error counts and small form-factor plug (SFP) information for each Fibre Channel port on the drive.

TABLE 3-41 Vendor Port Statistics Page Codes

Parameter Code	Description	Length (Bytes)	Default Threshold
0100h	Port A link failure count	4	FFFFFFFF
0101h	Port A loss of sync count	4	FFFFFFFF
0102h	Port A loss of signal count	4	FFFFFFFF
0103h	Port A prim seq errors count	4	FFFFFFFF
0104h	Port A invalid transmit word count	4	FFFFFFFF
0105h	Port A invalid CRC count	4	FFFFFFFF
0110h	Port A SFP missing	4	FFFFFFFF
0111h	Port A SFP loss of signal	4	FFFFFFFF
0112h	Port A SFP fault	4	FFFFFFFF
0120h	Port A SCSI command count	8	FFFFFFFF FFFFFFFF
0121h	Port A SRR count	4	FFFFFFFF
0200h	Port B link failure count	4	FFFFFFFF
0201h	Port B loss of sync count	4	FFFFFFFF
0202h	Port B loss of signal count	4	FFFFFFFF
0203h	Port B prim seq error count	4	FFFFFFFF
0204h	Port B invalid transmit word count	4	FFFFFFFF
0205h	Port B invalid CRC count	4	FFFFFFFF
0210h	Port B SFP missing	4	FFFFFFFF
0211h	Port B SFP loss of signal	4	FFFFFFFF
0212h	Port B SFP fault	4	FFFFFFFF
0220h	Port B SCSI command count	8	FFFFFFFF FFFFFFFF
0221h	Port B SRR count	4	FFFFFFFF
1100h	Port A SFP ID block	128	all 00's
1110h	Port A SFP monitor block	128	all 00's
1200h	Port B SFP ID block	128	all 00's
1210h	Port B SFP monitor block	128	all 00's

Vendor Unique Drive Statistics Page

The T10000C Vendor Unique Drive Statistics page (3Ch) reports a variety of vendor unique drive statistics.

TABLE 3-42 T10000C Vendor Drive Statistics Page Codes

Parameter Code	Description	Length (Bytes)	Default Threshold
0100h	Read forward data checks	4	all FF's
0101h	Write data checks	4	all FF's
0102h	Read data checks without hardware	4	all FF's
0103h	Write data checks without hardware	4	all FF's
0104h	Read recovery retry count	4	all FF's
0105h	Read transient conditions	4	all FF's
0106h	Write transient conditions	4	all FF's
0107h	Servo temporaries	4	all FF's
0108h	Servo transients	4	all FF's
0109h	Corrections 2t	4	all FF's
010Ah	Matrices with pw1 and pw2	4	all FF's
010Bh	Matrices with pws	4	all FF's
010Ch	Progressive write for ind channels	4	all FF's
010Dh	Progressive write type 1	4	all FF's
010Eh	Progressive write type 2	4	all FF's
0110h	Pw sot leading head	4	all FF's
0111h	Sot trailing head	4	all FF's
0112h	Write recovery retry count	4	all FF's
0114h	Pwc matrix count	4	all FF's
0115h	Sot leading head	4	all FF's
0200h	Read data request timeouts	4	all FF's
0201h	Write data request timeouts	4	all FF's
0202h	Data transfer errors	4	all FF's
0203h	Temporary drive errors	4	all FF's
0204h	Perm errors logged	4	all FF's
0300h	Channel read bytes processed	8	all FF's
0301h	Device read bytes processed	8	all FF's
0302h	Channel write bytes processed	8	all FF's
0303h	Device write bytes processed	8	all FF's
0304h	Channel read blocks processed	8	all FF's

TABLE 3-42 T10000C Vendor Drive Statistics Page Codes (Continued)

Parameter Code	Description	Length (Bytes)	Default Threshold
0305h	Channel write blocks processed	8	all FF's
0306h	Device read blocks processed	8	all FF's
0307h	Device write blocks processed	8	all FF's
0308h	Read write servo position units	8	all FF's
0309h	High speed servo position units	8	all FF's
030Ah	Servo position units	8	all FF's
030Bh	Tape reposition cycles	4	all FF's
030Ch	Time spent writing	8	all FF's
030Dh	Time spent reading	8	all FF's
030Eh	Tape over under reposition cycles	4	all FF's
030Fh	Servo position units native	8	all FF's
0310h	Time tape reloaded	8	all FF's
0311h	Time tape in motion for read write	8	all FF's
0312h	Time tape in motion for position	8	all FF's
0400h	Tape efficiency (*see notes*)	4	all FF's
0401h	Read quality (*see notes*)	4	all FF's
0402h	Read back quality (*see notes*)	4	all FF's
0403h	Host dia detected error	4	all FF's
0404h	Servo statistics flags	4	all FF's
0405h	Exp prml blk cnt rev	4	all FF's
0406h	Exp prml blk cnt fwd	4	all FF's
0407h	Write efficiency (*see notes*)	4	all FF's
1000h	Outer ECC multi symbol correction	64	all FF's
1100h	Servo general purpose counter head 0	16	all FF's
1101h	Servo general purpose counter head 1	16	all FF's
1200h	Servo vote out head 0	32	all FF's
1201h	Servo vote out head 1	32	all FF's
1202h	Servo no data available head 0	32	all FF's
1203h	Servo no data available head 1	32	all FF's
1310h	PES histogram head 0 A	128	all FF's
1311h	PES histogram head 0 B	128	all FF's
1320h	PES histogram head 1 A	128	all FF’s
1321h	PES histogram head 1 B	128	all FF’s

TABLE 3-42 T10000C Vendor Drive Statistics Page Codes (Continued)

Parameter Code	Description	Length (Bytes)	Default Threshold
1400h	Old VR^2 blocks	128	all FF's
1401h	Channel viterbi average	128	all FF's
1402h	Channel fr2 corrections	128	all FF's
1403h	Matrix channel dead	128	all FF's
1404h	Block crc error	128	all FF's
1405h	Prml block error rev	128	all FF's
1406h	Prml block error fwd	128	all FF's
1407h	Channel viterbi_divisor	128	all FF's
2100h	Read forward data checks legacy	4	all FF's
2102h	Read data checks without hardware legacy	4	all FF's
2104h	Read recovery retry count legacy	4	all FF's
2105h	Read transient conditions legacy	4	all FF's
2107h	Servo temporaries legacy	4	all FF's
2108h	Servo transients legacy	4	all FF's
2109h	Corrections 2t legacy	4	all FF's
2204h	Perm errors logged legacy	4	all FF's
2300h	Channel read bytes processed legacy	8	all FF's
2301h	Device read bytes processed legacy	8	all FF's
2304h	Channel read blocks processed legacy	8	all FF's
2306h	Device read blocks processed legacy	8	all FF's
2401h	Read quality legacy	4	all FF's
2405h	Exp prml blk cnt rev 0 15 legacy	4	all FF's
2406h	Exp prml blk cnt rev 16 31	4	all FF's
2407h	Exp prml blk cnt fwd 0 15	4	all FF's
2408h	Exp prml blk cnt fwd 16 31	4	all FF's
3000h	Outer ecc multi symbol correction legacy	64	all FF's
3405h	Prml block error rev legacy	128	all FF's
3406h	Prml block error fwd legacy	128	all FF's
3500h-351Dh	Reserved 0 – Reserved 1F	4 each (120 total)	all FF's

Notes:

- The device write byte count will include file marks and pad bytes. These additional bytes will not be included in the device read byte count.

- Parameters 0400 - 0402, and 0407 will not be reset by a Log Select command.

The T10000D Vendor Unique Drive Statistics page (3Dh) reports a variety of vendor unique drive statistics.

TABLE 3-43 T10000D Vendor Drive Statistics Page Codes

Parameter Code	Description	Length (Bytes)	Default Threshold
0100h	Read Forward Data Checks - Temporary	4	all FF's
0101h	Write Data Checks - Temporary	4	all FF's
0102h	Read Data Checks Without Hardware Indicators - Temporary	4	all FF's
0103h	Write Data Checks Without Hardware Indicators - Temporary	4	all FF's
0104h	Read Recovery Retry Count	4	all FF's
0105h	Read Transient Conditions	4	all FF's
0106h	Write Transient Conditions	4	all FF's
0107h	Servo Temporaries	4	all FF's
0108h	Servo Transient Conditions	4	all FF's
0109h	2T Corrections (2TE)	4	all FF's
010Ah	Matrices with Progressive Write 1 or 2 (MPWD)	4	all FF's
010Bh	Matrices with Progressive Writes (MPWS)	4	all FF's
010Ch	Progressive Write for Indicated Channels (PWC)	4	all FF's
010Dh	Progressive Write for Data; Mode 1 (PW1)	4	all FF's
010Eh	Progressive Write for Data; Mode 2 (PW2)	4	all FF's
0110h	PW SOT (Leading Head) (PWSOT)	4	all FF's
0111h	SOT Trailing Head (SOTT)	4	all FF's
0112h	Write Recovery Retry Count	4	all FF's
0114h	PWC Matrix Count	4	all FF's
0115h	SOT Leading Head (SOTL)	4	all FF's
0116h	Matrix Count	4	all FF's
0117h	PW2 Matrix Count	4	all FF's
0118h	Maximum Append PWS COunt	4	all FF's
0120h	Maximum PWD Written Stripe Count	4	all FF's
0121h	PWD Matrix Count	4	all FF's
0122h	PWD Written Stripe Count	4	all FF's
0200h	Read Data Request Timeouts	4	all FF's
0201h	Write Data Request Timeouts	4	all FF's

TABLE 3-43 T10000D Vendor Drive Statistics Page Codes (Continued)

Parameter Code	Description	Length (Bytes)	Default Threshold
0202h	Data Transfer Errors - excluding data request timeouts	4	all FF's
0203h	Temporary Drive Errors	4	all FF's
0204h	Permanent Errors Logged	4	all FF's
0300h	Channel Read Bytes Processed	8	all FF's
0301h	Device Read Bytes	8	all FF's
0302h	Channel Write Bytes Processed	8	all FF's
0303h	Device Write Bytes Processed	8	all FF's
0304h	Channel Read Blocks Processed	8	all FF's
0305h	Channel Write Blocks Processed	8	all FF's
0306h	Device Read Blocks Processed	8	all FF's
0307h	Device Write Blocks Processed	8	all FF's
0308h	Read/Write Distance Crossed	8	all FF's
0309h	Position Distance Crossed	8	all FF's
030Bh	Tape Reposition Cycles	4	all FF's
030Ch	Time Spent Writing	8	all FF's
030Dh	Time Spent Reading	8	all FF's
030Eh	Repositions Due to Overrun/ Underrun	4	all FF's
030Fh	Total Distance Crossed (TDistC)	8	all FF's
0310h	Time Tape Loaded	8	all FF's
0311h	Time Tape Was In Motion for Read/Write	8	all FF's
0312h	Time Tape Was In Motion for Position	8	all FF's
0313h	Read/Write Distance Crossed at Speed 4	8	all FF's
0314h	Read/Write Distance Crossed at Speed 3	8	all FF's
0315h	Read/Write Distance Crossed at Speed 2	8	all FF's
0316h	Read/Write Distance Crossed at Low Speed	8	all FF's
0400h	Tape Efficiency (TEFF) (*see notes*)	4	all FF's
0401h	Read Quality Index (RdQI) (*see notes*)	4	all FF's
0402h	Read Back Check Quality Index (WQI) (*see notes*)	4	all FF's
0403h	Host/Dia Detected Error (HDE)	4	all FF's
0404h	Servo Stats Flags	4	all FF's
0407h	Write Efficiency (WEFF) (*see notes*)	4	all FF's
0408h	Tape Format (*see notes*)	4	all FF's

TABLE 3-43 T10000D Vendor Drive Statistics Page Codes (Continued)

Parameter Code	Description	Length (Bytes)	Default Threshold
1000h	Outer ECC Multi-Symbol Correction (MSCx)	64	all FF's
1100h	Servo General Purpose Counter Head 0 (SGPCT0)	16	all FF's
1101h	Servo General Purpose Counter Head 1 (SGPCT1)	16	all FF's
1200h	Servo Vote Out Head 0 (SVO0)	32	all FF's
1201h	Servo Vote Out Head 1 (SVO1)	32	all FF's
1202h	Servo Off-Track Type Head 0 (SOTT0)	32	all FF's
1203h	Servo Off-Track Type Head 1 (SOTT1)	32	all FF's
1310h	PES Histogram Head 0 A (PESH0)	128	all FF's
1311h	PES Histogram Head 0 B (PESH0)	128	all FF's
1320h	PES Histogram Head 1 A (PESH 1)	128	all FF's
1321h	PES Histogram Head 1 B (PESH 1)	128	all FF's
1400h	Old VR2 Blocks (VOLD)	128	all FF's
1402h	Channel FR2 Corrections (CFC)	128	all FF's
1404h	Block CRC Error (CBC)	128	all FF's
1405h	PRML Block Errors Reverse BLKERRr	128	all FF's
1406h	PRML Block Errors Forward BLKERRf	128	all FF's
1500h	Channel Viterbi Averages Rev	128	all FF's
1501h	Channel Viterbi Averages Fwd	128	all FF's
1502h	Channel Viterbi Divisor Rev	128	all FF's
1503h	Channel Viterbi Divisor Fwd	128	all FF's
1504h	Matrix Channel Dead Reverse	128	all FF's
1505h	Matrix Channel Dead Forward	4	all FF's
2405h	Exp Block Count Rev Chan 0-15	4	all FF's
2406h	Exp Block Count Rev Chan 16-31	4	all FF's
2407h	Exp Block Count Fwd Chan 0-15	4	all FF's
2408h	Exp Block Count Fwd Chan 16-31	4	all FF's
2500h	MIR Matrix Count on Write	4	all FF's
2501h	MIR Matrix Count on Read (*see notes*)	4	all FF's
2502h-251Fh	Engineering Use Only	4 each (120 total)	all FF's

Notes:

- The device write byte count will include file marks and pad bytes. These additional bytes will not be included in the device read byte count.

- Parameters 0400-0402, 0407-0408, and 2501 will not be reset by a Log Select command.

Volume Statistics Log Page

The Volume Statistics page (17h) reports parameters associated with utilization of the tape cartridge and medium. Only parameter 0203h used native capacity of partitions is supported.

TABLE 3-44 Volume Statistics Log Page

Byte	Bit 7	6	5	4	3	2	1	0
0	DS	SPF	Page Code (17h)					
1	Subpage Code							
2 thru 3	(MSB) Page Length (n-3) (LSB)							
Volume Statistics log parameter(s)								
4	Volume Statistics log parameter (first)							
n	Volume Statistics log parameter (last)							

Parameter	Value
DS: Disable Save	1 = Log parameters are not saved.
SPF: Subpage Format	0 = Only subpage 00h supported
Subpage code	00h = Subpage 0
Page length	Length of parameter data to follow
Volume statistics log parameters (first)	First log parameter in numerical order by parameter code
Volume statistics log parameters (last)	Last log parameter in numerical order by parameter code

Volume Statistics Log Parameter 0203h reports the used native capacity in MB (10^6 bytes) for each partition on the tape. The parameter uses the Volume Statistics Partition Record Descriptor format shown in TABLE 3-45.

TABLE 3-45 Volume Statistics Partition Record Log Parameter Format

Byte	Bit 7	6	5	4	3	2	1	0
0 thru 1	(MSB) Parameter code (LSB)							
2	DU	DS	TSD(0b)	ETC	TMC		Format and linking(11b)	
3	Parameter length (n-3)							
Volume statistics partition record descriptor(s)								
4	Volume statistics partition record descriptor (first)							
. . .								
n	Volume statistics partition record descriptor (last)							

Parameter	Value
Parameter code	Defines volume statistics data parameter
	0203h = Used native capacity of partitions in MB (10^6 bytes)
DU: Disable update	0 = Drive updates log parameter value
DS: Disable save	1 = saving the log is not supported
TSD: Target save	0 = Target provides a defined method of saving log parameters
ETC: Enable threshold comparison	0 = Comparison not performed
TMC: Threshold met criteria	00b = Every update of cumulative value
Format and linking	11b = binary format list
Parameter length	Number of bytes in the volume statistics partition record descriptors

The value of the log parameter for each partition is reported in the format shown in TABLE 3-46.

TABLE 3-46 Volume Statistics Partition Record Descriptor Format

Byte	Bit 7	6	5	4	3	2	1	0
0	Partition record descriptor length (n)							
1	Reserved							
2 thru 3	(MSB) Partition number (LSB)							
4 thru n	(MSB) Partition record data counter (LSB)							

Parameter	Value
Partition record descriptor length	7 = Number of byte that follow
Partition Number	Number of partition that the following counter is associated.
Partition record data counter	Value of data counter associated with parameter code and partition

Mode Select Command

The Mode Select command specifies options and parameters for a device. StorageTek recommends the host system perform a Mode Sense command before each Mode Select command to determine the current settings and to avoid any unwanted alterations to other Mode Select fields.

The Mode Sense command determines which fields can be changed by the Mode Select command and what the default values are for these fields.

The tape drives support both 6- and 10-byte commands.

TABLE 3-47 Mode Select (10)—6 Byte Command

Byte	Bit 7	6	5	4	3	2	1	0
0	Operation Code (15h)							
1	Reserved			PF	Reserved			SP
2 thru 3	(MSB) Reserved (LSB)							
4	Parameter List Length							
5	Control Byte							

TABLE 3-48 Mode Select (10)—10 Byte Command

Byte	Bit 7	6	5	4	3	2	1	0
0	Operation Code (55h)							
1	Reserved			PF	Reserved			SP
2 thru 6	(MSB) Reserved (LSB)							
7 thru 8	(MSB) Parameter List Length (LSB)							
9	Control Byte							

Mode Select data consists of a header, an optional block descriptor, and optional page formatted data:

Parameter	Value
PF: Page Format	0 = Vendor specific format (same as PF = 1) 1 = Page formatted data follows block descriptor, or header
SP: Save Parameters	0 = Not supported
Parameter List Length	Contains the total number of bytes in the header, block descriptor, and all pages. If this length is 0, no mode select data is sent and the command is ignored. If this length results in the truncation of the header, block descriptor, or any page, the command is rejected. Mode select data can be sent as: • Header only • Header and page formatted data • Header and block descriptor • Header, block descriptor, and page formatted data Pages can be sent in any order. If any page formatted data is sent, the PF bit is set in the command.

Mode Select Header Data

TABLE 3-49 Mode Select (6) Header Data

Byte	Bit 7	6	5	4	3	2	1	0
0 thru 1	(MSB) Reserved (LSB)							
2	N/A	Buffered Mode			Speed Code			
3	Block Descriptor Length							

TABLE 3-50 Mode Select (10) Header Data

Byte	Bit 7	6	5	4	3	2	1	0
0 thru 2	(MSB) Reserved (LSB)							
3	0	Buffered Mode			Speed Code			
4 thru 5	(MSB) Reserved (LSB)							
6 thru 7	(MSB) Block Descriptor Length (LSB)							

Page data may follow header if 00 is returned for block descriptor length.

Parameter	Value
N/A	Not applicable or not defined
Buffered Mode	000b = Return status after data is on tape
	001b = Return status when data is in the buffer
Speed Code	0h = Use default speed
	1h = Lowest speed
	2h = Next lowest speed
	3h = Medium speed
	4h = Next highest speed
	5h = Highest speed
Block Descriptor Length	00 = No Block Descriptor
	08 = Block Descriptor follows
	Page data follows header if 00 is returned for block descriptor length.

Mode Select Block Descriptor Data

TABLE 3-51 Mode Select Block Descriptor Data

Byte	Bit 7	6	5	4	3	2	1	0
0	Density Code							
1 thru 3	(MSB) Block Count (LSB)							
4	Reserved							
5 thru 7	(MSB) Block Length (LSB)							

Parameter	Value
Density Code	00h = Default density 4Ah = T10000A default density 4Bh = T10000B default density 4Ch = T10000C default density 4Dh = T10000D default density 7Fh = Do not change density
Block Count	Must be 0
Block Length	Variable block mode length is 0 Fixed block mode length 1 to 2,097,152 bytes **Note –** 2,097,156 bytes is now the upper limit in fixed block mode when the DIV mode is enabled. See “Control Data Protection Mode Page” on page 97

Read/Write Error Recovery Page

TABLE 3-52 Mode Select Read/Write Error Page

Byte	Bit 7	6	5	4	3	2	1	0
0	PS	SFP (0)	Page Code (01h)					
1	Page Length (0Ah)							
2	Reserved		TB	RSVD	ERR	PER	DTE	DCR
3	Read Retry Count							
4 thru 7	(MSB) Reserved (LSB)							
8	Write Retry Count							
9 thru 11	(MSB) Reserved (LSB)							

Parameter	Value	
PS: Parameters Savable	0 = Not supported	
SPF: SubPage Format	0 = Mode page format	
TB: Transfer Block	0 = Unrecoverable data block not transferred	
ERR: Enable Early Recovery	0 = Normal error recovery	
PER: Post Error	0 = Normal mode	
DTE: Disable Transfer on Error	0 = Normal mode	
DCR: Disable Correction	0 = Always use error correction codes	
Read Retry Count	Extent of error recovery during read operations	
	Count ignored, always maximum recovery	
WriteRetry Count	**Extent of error recovery during the write operations**	
	0h	5 minutes (same as default)
	1h – 13h	10 seconds
	14h – 3Bh	1 minute
	3Ch – 63h	3 minutes
	64h – 77h	5 minutes
	78h – C7h	6 minutes
	C8h – FFh	10 minutes
	64h	Default value (5 minutes)

Disconnect–Reconnect Page

TABLE 3-53 Mode Select Disconnect–Reconnect Page

Byte	Bit 7	6	5	4	3	2	1	0
0	PS	SPF (0)	Page Code (02h)					
1	Page Length (0Eh)							
2	Buffer full ratio							
3	Buffer empty ratio							
4 thru 5	(MSB) Bus inactivity limit (LSB)							
6 thru 7	(MSB) Disconnect time limit (LSB)							
8 thru 9	(MSB) Connect time limit (LSB)							
10 thru 11	(MSB) Maximum burst size (LSB)							
12	EMDP	FARd	FAWrt	FAStat	DImm	DTDC		
13	Reserved							
14 thru 15	(MSB) First burst size (LSB)							

Parameter	Value
PS: Parameters Savable	0 = Not supported
SPF: SubPage Format	0 = Mode page format
Buffer Full Ratio	0 = Not supported
Buffer Empty Ratio	0 = Not supported
Bus Inactivity Limit	0 = Not supported
Disconnect Time Limit	0 = Not supported
Connect Time Limit	0 = Not supported
Maximum Burst Size	0 = No limit
EMDP: Enable Modify Data Pointers	0 = Modify data pointers is disabled
FARd: Loop Fairness Algorithm Read	0 = Target chooses
FAWrt: Loop Fairness Algorithm Write	0 = Target chooses

Parameter	Value
FAStat: Loop Fairness Algorithm Status	0 = Target chooses
DImm: Disconnect Immediate	0 = Target chooses
DTDC: Data transfer disconnect control	0 = Target chooses
First Burst Size	0 = No limit

Control Data Protection Mode Page

This Mode Select page returns information about the current Data Integrity Validation (DIV) mode.

The Mode Select Block Descriptor Data, Block Length field now has 2,097,156 for the upper limit in fixed block mode when the DIV mode is enabled.

TABLE 3-54 Mode Select Control Data Protection Mode Page

Byte	Bit 7	6	5	4	3	2	1	0
0	PS	SPF (1)	Page Code (0Ah)					
1	Subpage Code (F0h)							
2 thru 3	(MSB) Page Length (n-3) (LSB)							
4	Logical Block Protection Information Method							
5	Reserved		Logical Block Protection Information Length					
6	LBP_W	LBP_R	RBDP	Reserved				
7	T10 PI Exponent				Reserved			
n	Reserved							

Parameter	Value
PS: Parameters Savable	0 = Not supported
SPF: SubPage Format	1 = SubPage mode format
Subpage code	F0h = Control Data Protection mode page
Logical Block Protection	See TABLE 3-55. • Information Method • Information Length

Parameter	Value
LBP_W Logical Blocks Protected during	0 = Protection Information is not included with the data transferred when writing. 1 = Protection Information is included with the data transferred when writing. **Notes:** • If the Logical Block Protection Method field is set to zero, the LBP_W bit is set to zero. • If Logical Block Protection Method field is set to a non-zero, then one or more of LBP_W or LBP_R bits must be set to a non-zero.
LBP_R: Logical Blocks Protected Read	0 = Protection Information is not included with the data transferred when reading. 1 = Protection Information is included with the data transferred when reading. **Notes:** If the Logical Block Protection Method field is set to zero, the LBP_R bit is set to zero. If the Logical Block Protection Method field is set to a non-zero then one or more of LBP_W or LBP_R bits must be set to a non-zero.
RBDP: Recover Buffered Data Protected	0 = Protection Information is not included with the data transferred by the Recover Buffered Data command. 1 = Protection Information is included with the data transferred by the Recover Buffered Data command. (This bit is Ignored). **Notes:** • If the Logical Block Protection Method field is set to zero, the RBDP bit is set to zero. • If Logical Block Protection Method field is set to a non-zero then this bit is ignored.

Parameter	Value
LBP_W Logical Blocks Protected during	0 = Protection Information is not included with the data transferred when writing. 1 = Protection Information is included with the data transferred when writing. **Notes:** • If the Logical Block Protection Method field is set to zero, the LBP_W bit is set to zero. • If Logical Block Protection Method field is set to a non-zero, then one or more of LBP_W or LBP_R bits must be set to a non-zero.
LBP_R: Logical Blocks Protected Read	0 = Protection Information is not included with the data transferred when reading. 1 = Protection Information is included with the data transferred when reading. **Notes:** If the Logical Block Protection Method field is set to zero, the LBP_R bit is set to zero. If the Logical Block Protection Method field is set to a non-zero then one or more of LBP_W or LBP_R bits must be set to a non-zero.
RBDP: Recover Buffered Data Protected	0 = Protection Information is not included with the data transferred by the Recover Buffered Data command. 1 = Protection Information is included with the data transferred by the Recover Buffered Data command. (This bit is Ignored). **Notes:** • If the Logical Block Protection Method field is set to zero, the RBDP bit is set to zero. • If Logical Block Protection Method field is set to a non-zero then this bit is ignored.

Parameter	Value
T10 PI Exponent: (T10000D)	This field determines the size of each user data field (in bytes) when T10 PI protected mode is selected. 0h = 1 bytes 1h = 2 2h = 4 3h = 8 4h = 16 5h = 32 6h = 64 7h = 128 8h = 256 9h = 512 Ah = 1,024 Bh = 2,048 Ch = 4,096 Dh = 8,192 Eh = 16,384 Fh = 32,768 T10000D only supports exponent values 9h through Fh.

TABLE 3-55 Protection Information Method

Method (Byte 4)	Description	Length (Byte 5)	Drives Supported
00h	Do not use logical block protection.	00h	T10000 All
01h	Reed-Solomon CRC, See ECMA-319[1], CRC appended on any byte boundary	04h	T10000C and T10000D
02h - EFh	Reserved	–	–
F0h	Vendor Unique SB-2, CRC appended on modulo 4 byte boundary	04h	T10000A T10000B
F1h	Vendor Unique Intel CRC32C, CRC appended on any byte boundary	04h	T10000C and T10000D
F2h	Vendor Unique T10 PI PI appended on each user data field	08h	T10000D
F3h - FFh	Reserved	–	–

1. European Computer Manufacturers Association “Data Interchange on 12.7 mm 384-Track magnetic Tape Cartridges,” ECMA-319 Standard, 2001.

Data Compression Page

TABLE 3-56 Mode Select Data Compression Page

Byte	Bit 7	6	5	4	3	2	1	0
0	PS	SPF (0)	Page Code (0Fh)					
1	Page Length (0Eh)							
2	DCE	DCC	Reserved					
3	DDE	RED		Reserved				
4 thru 7	(MSB) Compression Algorithm (LSB)							
8 thru 11	(MSB) Decompression Algorithm (LSB)							
12 thru 15	(MSB) Reserved (LSB)							

Parameter	Value
PS: Parameters Savable	0 = Not supported
SPF: SubPage Format	0 = Mode page format
DCE: Data Compression Enabled	0 = Data compression on writes is disabled
	1 = Data compression on writes is enabled
DCC: Data Compression Capable	Controlled by operator configuration menu, not changeable
	0 = Not supported
	1 = Supported
DDE: Data Decompression Enable	1 = Data decompression on reads is enabled
RED: Report Exception on Decompression	0b = Not supported
Compression Algorithm	00h = No compression algorithm
	01h = Default algorithm
Decompression Algorithm	00h = No decompression algorithm
	01h = Default algorithm

Device Configuration Page

TABLE 3-57 Mode Select Device Configuration Page

Byte	Bit 7	6	5	4	3	2	1	0
0	PS	SPF (0)	Page Code (10h)					
1	Page Length (0Eh)							
2	RSVD	CAP	CAF	Active Format				
3	Active Partition							
4	Write Buffer Full Ratio							
5	Read Buffer Empty Ratio							
6 thru 7	(MSB) Write Delay Time (LSB)							
8	DBR	BIS	RSMK	AVC	SOCF		RBO	REW
9	Gap Size							
10	EOD Defined			EEG	SEW	SWP	Reserved	
11 thru 13	(MSB) Buffer Size at Early Warning (LSB)							
14	Select Data Compression Algorithm							
15	Reserved					ASOCWP	PERSWP	PRMWP

Parameter	Value
PS: Parameters Savable	0 = Not supported
SPF: SubPage Format	0 = Mode page format
CAP: Change Active Partition	0 = Active partition not changeable
CAF: Change Active Format	0 = Active format not changeable
Active Format	0 = Default format not changeable
Active Partition	0 = Default partition not changeable
Write Buffer Full Ratio	0 = Controlled by device
Read Buffer Empty Ratio	0 = Controlled by device
Write Delay Time	64h = 10 seconds
DBR: Data Buffer Recovery	0 = Recover buffered data not supported
BIS: Block IDs Supported	1 = Tape format includes block ID
RSMK: Report Setmarks	0 = Setmarks not supported
AVC: Automatic Velocity Control	1 = Speed automatically selected

Parameter	Value
SOCF: Stop On Consecutive Filemarks	00b = Stop read ahead when buffer is full
RBO: Recover Buffer Order	0 = Not supported
REW: Report Early Warning	0 = Report early warning only on Write and Write Filemarks commands
Gap Size	0 = Gap size not selectable
EOD Defined: End Of Data	000b = Default EOD only
EEG: EOD Enabled Generation	1 = EOD generated per EOD field
SEW: Synchronize at Early Warning Logical End-of-Tape (LEOT)	0 = Buffered write data and filemarks not flushed to tape when LEOT detected
	1 = Buffered write data and filemarks written to tape when LEOT detected
SWP: Soft Write Protect	0 = Not supported
Buffer Size at Early Warning	0 = Buffer size not selectable
Select Algorithm: Select Data Compression Algorithm	00h = No data compression 01h = LZ1 compression of write records
	Note – The Select Algorithm field will be ignored if Mode Page 0Fh (Data Compression) is also sent in the same Mode Select command.
ASOCWP: Associated Write Protect	0 = Not supported
PERSWP: Persistent Write Protect	0 = Not supported
PRMWP: Permanent Write Protect	0 = Not supported

Fibre Channel Logical Unit Control Page

TABLE 3-58 Fibre Channel Logical Unit Control Page (18h)

Byte	Bit 7	6	5	4	3	2	1	0
0	PS	SPF (0)	Page Code (18h)					
1	Page Length (06h)							
2	Reserved							
3	Reserved							EPDC
4 thru 7	(MSB) Reserved (LSB)							

Parameter	Value
PS: Parameters Savable	0 = Not supported
SPF: SubPage Format	0 = Mode page format
EPDC: Enable Precise Delivery Checking	0 = Not supported

Fibre Channel Port Control Page

TABLE 3-59 Fibre Channel Port Control Page (19h)

Byte	Bit 7	6	5	4	3	2	1	0
0	PS	SPF (0)	Page Code (19h)					
1	Page Length (06h)							
2	Reserved							
3	DTFD	PLPB	DDIS	DLM	DSA	ALWI	DTIPE	DTOLI
4 thru 5	(MSB) Reserved (LSB)							
6	Reserved					RR_TOV units		
7	Resource Recovery Time Out Value (RR_TOV)							

Parameter	Value
PS: Parameters Savable	0 = Not supported
SPF: SubPage Format	0 = Mode page format
DTFD: Disable Target Fabric Discovery	0 = Not supported
PLPB: Prevent Loop Port Bypass	0 = Not supported
DDIS: Disable Discovery	0 = Not supported
DLM: Disable Loop Master	0 = Not supported
DSA: Disable Soft Address	0 = Not supported
ALWI: Allow Login Without Loop Initialization	0 = Not supported
DTIPE: Disable Target Initiated Port Enable	0 = Not supported
DTOLI: Disable Target Originated Loop Initialization	0 = Not supported
RR_TOV units	101b = 10 second units
RR_TOV value	1Eh = 300 seconds

TapeAlert Page

TABLE 3-60 Mode Select TapeAlert Page

Byte	Bit 7	6	5	4	3	2	1	0
0	PS	SPF (0)	Page Code (1Ch)					
1	Page Length (0Ah)							
2	Perf	Reserved		EWasc	DExcpt	Test	RSVD	LogErr
3	Reserved				MRIE (3h)			
4 thru 7	(MSB) Interval Timer (LSB)							
8 thru 11	(MSB) Report Counter / Test Flag Number (LSB)							

Parameter	Value
PS: Parameters Savable	0 = Not supported
SPF: SubPage Format	0 = Mode page format
Perf: Performance	0 = Informational exception operations that cause delays are acceptable
EWasc: Early Warning	0 = Disable reporting of warning, MRIE Field, ignored
DExcpt: Disable Exception	1 = Target disables all information exception operations ignoring the MRIE field. In this mode the software must poll the TapeAlert Log page.
Test: Test operations	0 = Do not generate any false/test informational exception conditions
LogErr: Log Errors	0 = Logging of informational exception conditions is vendor-specific
MRIE: Method used to Report Informational Exception conditions	0h = No reporting of informational exception conditions, ignored
Interval Timer	Must be 0
Report Count/Test Flag Number	Must be 0

Medium Configuration Page

Mode select page 11h controls tape partitioning.

TABLE 3-61 Mode Select Medium Configuration Page

Byte	Bit 7	6	5	4	3	2	1	0
0	PS	SPF (0)	Page Code (1Dh)					
1	Page Length (1Eh)							
2	Reserved							WORMM
3	Reserved							
4	WORM Mode Label Restrictions							
5	WORM Mode Filemark Restrictions							
6 thru 31	(MSB) Reserved (LSB)							

Parameter	Value
PS: Parameters Savable	0 = Not supported
SPF: SubPage Format	0 = Mode page format
WORMM: WORM mode	0 = Normal mode
	1 = WORM (VolSafe) mode
WORM Mode Label Restrictions	1 = Some types of format labels may be overwritten
WORM Mode Filemark Restrictions	2 = All but one filemark at the EOD may be overwritten.

Medium Partition Mode Page

Mode select page 11h controls tape partitioning.

TABLE 3-62 Mode Select Medium Partition mode page - T10000C and T10000D

Byte	Bit 7	6	5	4	3	2	1	0
0	PS (0)	SPF (1)	Page Code (11h)					
1	Page Length (1Eh)							
2	Maximum Additional Partitions							
3	Additional Partitions Defined							
4	FDP	SDP	IDP	PSM		POFM	CLEAR	ADDP
5	Medium Format Recognition							
6	Reserved				Partition Units			
7	Reserved							
8 thru 9	Partition 0 Size							
n-1 thru n	Partition n Size							

Parameter	Value
Page Length	Additional bytes in this mode page 0Ah = Mode page with two partitions - T10000C 08h - 1Ah = determined by the number of partitions defined - T10000D
Maximum Additional Partitions	Maximum number of additional partitions supported 1 = Always one when tape loaded (T10000C) 9 = Always nine when tape loaded (T10000D)
Additional Partitions defined	Number of additional partitions 0 = No additional partitions, tape has one default partition 1 = One additional partition, tape has two partitions (T10000C) 1-9 = Additional partitions (T10000D)
FDP: Fixed Data Partitions	0 = Not supported
SDP: Select Data Partitions	0 = Not supported
IDP: Initiator Defined Partitions	1 = Partitions defined by partition size descriptors
PSUM: Partition Size Unit of Measure	11b = $10^{(\text{partition units})}$ bytes

POFM: Partition On Format	1 = Partitioning occurs on subsequent Format Medium command
CLEAR: Logical erase	0 = Not supported
ADDP: Additional Partitions	0 = Not supported
Medium Format Recognition	03 = Logical unit capable of format and partition recognition (must be 03)
Partition Units	08 = 100 MB - T10000C 09 = 1 GB (08 when using partition sizes 0001h, FFFFh) - T10000D

TABLE 3-63 Allowed Partition Sizes - T10000C

Number of Partitions	Partition Number									
	0	1	2	3	4	5	6	7	8	9
2	0001h	FFFFh								

TABLE 3-64 Allowed Partition Sizes - T10000D

Number of Partitions	Partition Number									
	0	1	2	3	4	5	6	7	8	9
2	0001h	FFFFh								
2	000Bh	1F16h								
2	0C73h	12ADh								
3	0639h	0C73h	0C73h							
4	000Bh	0C68h	000Bh	12A2h						
4	0639h	0639h	0639h	0C73h						
5	0639h	0639h	0639h	0639h	0639h					
6	000Bh	062Eh	000Bh	0C68h	000Bh	0C68h				
8	000Bh	062Eh	000Bh	062Eh	000Bh	062Eh	000Bh	0C68h		
10	000Bh	062Eh	000Bh	062Eh	000Bh	062Eh	000Bh	062Eh	000Bh	062Eh

On the T10000D the size of the last partition may be FFFFh indicating that all remaining space is allocated to that partition. The actual size is the same.

Read/Write Control Page

Vendor unique page used to control writing to maximum tape capacity.

TABLE 3-65 Read/Write Control Page

Byte	Bit 7	6	5	4	3	2	1	0
0	PS	SPF (0)	Page Code (25h)					
1	Page Length (1Eh)							
2 thru 4	(MSB) Reserved (LSB)							
5	Reserved							AMC
6 thru 7	(MSB) Reserved (LSB)							
8	DFSA	LFA	Reserved					
9 thru 31	(MSB) Reserved (LSB)							

Parameter	Value
PS: Parameters Savable	0 = Not supported
SPF: SubPage Format	0 = Mode page format
AMC: Allow Maximum Capacity	0 = Constant capacity 1 = Maximum capacity Constant capacity is the advertised capacity of the media. Maximum capacity is the advertised capacity plus about 10% additional. **Note –** It is not recommended to use maximum capacity if a tape to tape copy will ever be attempted.
DFSA: Disable File Sync Accelerator	0 = FSA Enabled (default setting) 1 = Disable FSA File Sync Accelerator is a method that allows tape motions to continue when the host write rate drops below the tape speed
LFA: Large File Accelerator	0 = LFA disabled (default setting) 1 = LFA enabled

Note – Reserved bytes 2–4, 6–7, and 9–31 are ignored.

Mode Sense Command

The Mode Sense (6) and Mode Sense (10) commands return the current operating modes and parameters of a device to the host. The Mode Sense commands also return the default parameters or information on which fields and bits can be changed using the Mode Select command. The device returns a header, block descriptor, and one or all supported pages following the block descriptor.

Note – The tape drives support both 6- and 10-byte commands. The Mode Sense (10) command allows for a longer Allocation length, but otherwise operates identically to the Mode Sense (6) command.

TABLE 3-66 Mode Sense—6 Byte Command

	Bit							
Byte	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	Operation Code (1Ah)							
1	Reserved				DBD	Reserved		
2	PC		Page Code					
3	Subpage Code							
4	Allocation Length							
5	Control Byte							

TABLE 3-67 Mode Sense—10 Byte Command

	Bit							
Byte	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	Operation Code (5Ah)							
1	Reserved			LLBAA	DBD	Reserved		
2	PC		Page Code					
3	Subpage Code							
4 thru 6	(MSB) Reserved (LSB)							
7 thru 8	(MSB) Allocation Length (LSB)							
9	Control Byte							

Parameter	Value
LLBAA: Long LBA Accepted	0 = Normal
DBD: Disable Block Descriptor	0 = Return block descriptor after header
	1 = Do not return the block descriptor
PC: Page Control	00b = Current values
	01b = Changeable values
	10b = Default values
Page Code: Mode page to return	00h = No page data
	01h = Read/Write Error Recovery page
	02h = Disconnect–Reconnect page
	0Ah = Control Data Protection Mode Page
	0Fh = Data Compression page
	10h = Device Configuration page
	18h = Fibre Channel Logical Unit Control page
	19h = Fibre Channel Port Control page
	1Ch = Tape Alert page
	1Dh = Medium Configuration page
	25h = Read/Write Control Page
	3Fh = All pages
Subpage Code	Subpage to return
Allocation Length	Maximum number of bytes to transfer to the host
	If both PC and Page Code are 00, no page data is returned.

Mode Sense Header Data

Mode Sense—6 Byte Command returns a 4-byte header.

TABLE 3-68 Mode Sense (6) Header Data

Byte	Bit 7	6	5	4	3	2	1	0
0	Mode Data Length							
1	Medium Type							
2	WP	Buffered Mode			Speed			
3	Block Descriptor Length							

Mode Sense—10 Byte Command returns an 8-byte header

TABLE 3-69 Mode Sense (10) Header Data

Byte	Bit 7	6	5	4	3	2	1	0
0 thru 1	(MSB) Mode Data Length (LSB)							
2	Medium Type							
3	WP	Buffered Mode			Speed			
4 thru 5	(MSB) Reserved (LSB)							
6 thru 7	(MSB) Block Descriptor Length (LSB)							

Parameter	Value
Medium Type	0 = Vendor-specific (reserved)
WP: Write Protect	0 = Not file-protected 1 = File-protected
Buffered Mode	000b = Return Status on write commands after the data is written on tape. 001b = Return status on write commands after data has been transferred to the drive’s data buffer
Speed	0 = Default speed 1h = Lowest speed 2h = Next lowest speed 3h = Medium speed 4h = Next highest speed 5h = Highest speed

Mode Sense Block Descriptor Data

TABLE 3-70 Mode Sense Block Descriptor Data

Byte	Bit 7	6	5	4	3	2	1	0
0	Density Code							
1 thru 3	(MSB) Block Count (LSB)							
4	Reserved							
5 thru 7	(MSB) Block Length (LSB)							

Parameter	Value
Density Code	4Ah = T10000A default density
	4Bh = T10000B default density
	4Ch = T10000C default density
	4Dh = T10000D default density
Block Count	Will always be 0
Block Length	Variable block mode length is 0
	Fixed block mode length 1 to 2,097,152 bytes
	Note: 2,097,156 bytes is now the upper limit in fixed block mode when the DIV mode is enabled.
	See "Control Data Protection Mode Page" on page 117

Read/Write Error Recovery Page

TABLE 3-71 Mode Sense Read/Write Error Recovery Page

Byte	Bit 7	6	5	4	3	2	1	0
0	PS	SPF (0)	Page Code (01h)					
1	Page Length (0Ah)							
2	Reserved		TB	RSVD	EER	PER	DTE	DCR
3	Read Retry Count							
4 thru 7	(MSB) Reserved (LSB)							
8	Write Retry Count							
9 thru 11	(MSB) Reserved (LSB)							

Parameter	Value	
PS: Parameters Savable	0 = Not supported	
SPF: SubPage Format	0 = Mode page format	
TB: Transfer Block	0 = Unrecoverable data block not transferred	
EER: Enable Early Recovery	0 = Normal error recovery	
PER: Post Error	0 = Normal mode	
DTE: Disable Transfer on Error	0 = Normal mode	
DCR: Disable Correction	0 = Always use error correction codes	
Read Retry Count	Extent of error recovery during read operations 64h = Default value, always maximum recovery	
WriteRetry Count	**Extent of error recovery during the write operations**	
	0h	5 minutes (same as default)
	1h – 13h	10 seconds
	14h – 3Bh	1 minute
	3Ch – 63h	3 minutes
	64h – 77h	5 minutes
	78h – C7h	6 minutes
	C8h – FFh	10 minutes
	64h	Default value (5 minutes)

Disconnect–Reconnect Page

TABLE 3-72 Mode Sense Disconnect–Reconnect Page

<table>
<tr><th rowspan="2">Byte</th><th colspan="8">Bit</th></tr>
<tr><th>7</th><th>6</th><th>5</th><th>4</th><th>3</th><th>2</th><th>1</th><th>0</th></tr>
<tr><td>0</td><td>PS</td><td>SPF (0)</td><td colspan="6">Page Code (02h)</td></tr>
<tr><td>1</td><td colspan="8">Page Length (0Eh)</td></tr>
<tr><td>2</td><td colspan="8">Buffer full ratio</td></tr>
<tr><td>3</td><td colspan="8">Buffer empty ratio</td></tr>
<tr><td>4
thru
5</td><td colspan="8">(MSB)
Bus Inactivity Limit
(LSB)</td></tr>
<tr><td>6
thru
7</td><td colspan="8">(MSB)
Disconnect Time Limit
(LSB)</td></tr>
<tr><td>8
thru
9</td><td colspan="8">(MSB)
Connect Time Limit
(LSB)</td></tr>
<tr><td>10
thru
11</td><td colspan="8">(MSB)
Maximum Burst Size
(LSB)</td></tr>
<tr><td>12</td><td>EMDP</td><td>FARd</td><td>FAWrt</td><td>FAStat</td><td>DImm</td><td colspan="3">DTDC</td></tr>
<tr><td>13</td><td colspan="8">Reserved</td></tr>
<tr><td>14
thru
15</td><td colspan="8">(MSB)
First Burst Size
(LSB)</td></tr>
</table>

Parameter	Value
PS: Parameters Savable	0 = Not supported
SPF: SubPage Format	0 = Mode page format
Buffer Full Ratio	0 = Not supported
Buffer Empty Ratio	0 = Not supported
Bus Inactivity Limit	0 = Not supported
Disconnect Time Limit	0 = Not supported
Connect Time Limit	0 = Not supported
Maximum Burst Size	0 = No limit
EMDP: Enable Modify Data Pointers	0 = Disabled
FARd: Loop Fairness Algorithm Read	0 = Target chooses
FAWrt: Loop Fairness Algorithm Write	0 = Target chooses

Parameter	Value
FAStat: Loop Fairness Algorithm Status	0 = Target chooses
DImm: Disconnect Immediate	0 = Target chooses
DTDC: Data transfer disconnect control	0 = Target chooses
First Burst Size	0 = No limit

Control Data Protection Mode Page

This Mode Sense page returns information about the current Data Integrity Validation (DIV) mode.

Mode Sense Block Descriptor Data, Block Length field now has 2,097,156 for the upper limit in fixed block mode when the DIV mode is enabled.

TABLE 3-73 Mode Sense Control Data Protection Mode Page

Byte	Bit 7	6	5	4	3	2	1	0
0	PS	SPF (1)	Page Code (0Ah)					
1	Subpage Code (F0h)							
2 thru 3	(MSB) Page Length (n-3) (LSB)							
4	Logical Block Protection Information Method							
5	Reserved		Logical Block Protection Information Length					
6	LBP_W	LBP_R	RBDP	Reserved				
7	T10 PI Exponent				Reserved			

Parameters	Value
PS: Parameters Savable	0 = Not supported
SPF: SubPage Format	1 = SubPage mode format
Subpage code	F0h = Control Data Protection mode page
Logical Block Protection	See TABLE 3-74 on page 119 • Information Method • Information Length

Parameters	Value
LBP_W Logical Blocks Protected during	0 = Protection Information is not included with the data transferred when writing. 1 = Protection Information is included with the data transferred when writing. **Note –** If the Logical Block Protection Method field is set to zero, the LBP_W bit is set to zero.
LBP_R: Logical Blocks Protected during Read	0= Protection Information is not included with the data transferred when reading. 1 = Protection Information is included with the data transferred when reading. Note: If the Logical Block Protection Method field is set to zero, the LBP_R bit is set to zero.
RBDP: Recover Buffered Data Protected	0 = Protection Information is not included with the data transferred by the Recover Buffered Data command. 1 = Protection information is included with the data transferred by the Recover Buffered Data command. (This bit is Ignored). **Notes:** If the Logical Block Protection Method field is set to zero, the RBDP bit is set to zero. If the Logical Block Protection Method field is set to a non-zero then this bit is ignored.
T10 PI Exponent:	This field determines the size of each user data field (in bytes) when T10 PI protected mode is selected. 0h = 1 bytes 1h = 2 2h = 4 3h = 8 4h = 16 5h = 32 6h = 64 7h = 128 8h = 256 9h = 512 Ah = 1,024 Bh = 2,048 Ch = 4,096 Dh = 8,192 Eh = 16,384 Fh = 32,768 T10000D only supports Exponent values 9h through Fh.

TABLE 3-74 Protection Information Method

Method (Byte 4)	Description	Length (Byte 5)	Drives Supported
00h	Do not use logical block protection.	00h	T10000 All
01h	Reed-Solomon CRC, See ECMA-319[1], CRC appended on any byte boundary	04h	T10000C and T10000D
02h - EFh	Reserved	–	–
F0h	Vendor Unique SB-2, CRC appended on modulo 4 byte boundary	04h	T10000A T10000B
F1h	Vendor Unique Intel CRC32C, CRC appended on any byte boundary	04h	T10000C and T10000D
F2	Vendor Unique T10 PI PI appended on each user data field	08h	T10000D
F3h - FFh	Reserved	–	–

1. European Computer Manufacturers Association “Data Interchange on 12.7 mm 384-Track magnetic Tape Cartridges,” ECMA-319 Standard, 2001.

Data Compression Page

TABLE 3-75 Mode Sense Data Compression Page

Byte	Bit 7	6	5	4	3	2	1	0
0	PS	SPF (0)	Page Code (0Fh)					
1	Page Length (0Eh)							
2	DCE	DCC	Reserved					
3	DDE	RED		Reserved				
4 thru 7	(MSB) Compression Algorithm (LSB)							
8 thru 11	(MSB) Decompression Algorithm (LSB)							
12 thru 15	(MSB) Reserved (LSB)							

Parameter	Value
PS: Parameters Savable	0 = Not supported
SPF: SubPage Format	0 = Mode page format
DCE: Data Compression Enabled	0 = Data compression on writes is disabled
	1 = Data compression on writes is enabled
DCC: Data Compression	Capable Controlled by operator configuration menu
	0 = Not supported
	1 = Supported
DDE: Data Decompression Enable	1 = Data decompression on reads is enabled
RED: Report Exception on Decompression	0 = Not supported
Compression Algorithm	01h = Default algorithm
Decompression Algorithm	01h = Default algorithm

Device Configuration Page

TABLE 3-76 Mode Sense Device Configuration Page

<table>
<tr><th rowspan="2">Byte</th><th colspan="8">Bit</th></tr>
<tr><th>7</th><th>6</th><th>5</th><th>4</th><th>3</th><th>2</th><th>1</th><th>0</th></tr>
<tr><td>0</td><td>PS</td><td>SPF (0)</td><td colspan="6">Page Code (10h)</td></tr>
<tr><td>1</td><td colspan="8">Page Length (0Eh)</td></tr>
<tr><td>2</td><td>RSVD</td><td>CAP</td><td>CAF</td><td colspan="5">Active Format</td></tr>
<tr><td>3</td><td colspan="8">Active Partition</td></tr>
<tr><td>4</td><td colspan="8">Write Buffer Full Ratio</td></tr>
<tr><td>5</td><td colspan="8">Read Buffer Empty Ratio</td></tr>
<tr><td>6 thru 7</td><td colspan="8">(MSB) Write Delay Time (LSB)</td></tr>
<tr><td>8</td><td>DBR</td><td>BIS</td><td>RSMK</td><td>AVC</td><td colspan="2">SOCF</td><td>RBO</td><td>REW</td></tr>
<tr><td>9</td><td colspan="8">Gap Size</td></tr>
<tr><td>10</td><td colspan="3">EOD Defined</td><td>EEG</td><td>SEW</td><td>SWP</td><td colspan="2">Reserved</td></tr>
<tr><td>11 thru 13</td><td colspan="8">(MSB) Buffer Size at Early Warning (LSB)</td></tr>
<tr><td>14</td><td colspan="8">Select Data Compression Algorithm</td></tr>
<tr><td>15</td><td colspan="5">Reserved</td><td>ASOCWP</td><td>PERSWP</td><td>PRMWP</td></tr>
</table>

Parameters	Value
PS: Parameters Savable	0 = Not supported
SPF: SubPage Format	0 = Mode page format
CAP: Change Active Partition	0 = Active partition not changeable
CAF: Change Active Format	0 = Active format not changeable
Active Format	0 = Default format not changeable
Active Partition	0 = Default partition not changeable
Write Buffer Full Ratio	0 = Controlled by device
Read Buffer Empty Ratio	0 = Controlled by device
Write Delay Time	64h = 10 seconds
DBR: Data Buffer Recovery	0 = Recovered buffer data not supported
BIS: Block IDs Supported	1 = Tape format includes block ID
RSMK: Report Setmarks	0 = Setmarks not supported
AVC: Automatic Velocity Control	1 = Speed automatically selected

Parameters	Value
SOCF: Stop On Consecutive Filemarks	00b = Stop read ahead when buffer is full
RBO: Recover Buffer Order	0 = Not supported
REW: Report Early Warning	0 = Report early warning only on Write and Write Filemarks commands
Gap Size	0 = Gap size not selectable
EOD Defined: End Of Data	000b = Default EOD only
EEG: EOD Enabled Generation	1 = EOD generated per EOD field
SEW: Synchronize at Early Warning (LEOT)	0 = Buffered write data and filemarks not flushed to the tape when LEOT is detected
	1 = Buffered write data and filemarks written to the tape when LEOT is detected
SWP: Soft Write Protect	0 = Not supported
Buffer Size at Early Warning	0 = Buffer size not selectable
Select Algorithm: Select Data Compression Algorithm	Default is operator configurable
	00h = No data compression
	01h = LZ1 compression of write records
ASOCWP: Associated Write Protect	0 = Not supported
PERSWP: Persistent Write Protect	0 = Not supported
PRMWP: Permanent Write Protect	0 = Not supported

Device Configuration Extension Mode Page

This page is returned for LTFS compatibility.

TABLE 3-77 Device Configuration Extenstion mode page

<table>
<tr><th rowspan="2">Byte</th><th colspan="8">Bit</th></tr>
<tr><th>7</th><th>6</th><th>5</th><th>4</th><th>3</th><th>2</th><th>1</th><th>0</th></tr>
<tr><td>0</td><td>PS (0)</td><td>SPF (1)</td><td colspan="6">Page Code (10h)</td></tr>
<tr><td>1</td><td colspan="8">Subpage Code (01h)</td></tr>
<tr><td>2-3</td><td colspan="8">Page Length(1Ch)</td></tr>
<tr><td>4</td><td colspan="4">Reserved</td><td>TARPF</td><td>TASER</td><td>TARPC</td><td>TAPLSD</td></tr>
<tr><td>5</td><td colspan="4">WRITE MODE</td><td colspan="4">SHORT ERASE MODE</td></tr>
<tr><td>6 thru 7</td><td colspan="8">PEWS</td></tr>
<tr><td>8</td><td colspan="7">Reserved</td><td>VCELBRE</td></tr>
<tr><td>9 thru 31</td><td colspan="8">(MSB) Reserved (LSB)</td></tr>
</table>

Parameter	Value
TARPF	0 = Not implemented
TASER	0 = Not implemented
TARPC	0 = Not supported
TAPLSD	0 = Not supported
WRITE MODE	0 = Not supported
SHORT ERASE MODE	2 = EOD mark recorded at beginning of long erase
PEWS	0 = Not supported
VCELBRE	0 = Not supported

Fibre Channel Logical Unit Control Page

TABLE 3-78 Fibre Channel Logical Unit Control Page (18h)

Byte	Bit 7	6	5	4	3	2	1	0
0	PS	SPF (0)	Page Code (18h)					
1	Page (06h)							
2	Reserved							
3	Reserved							EPDC
4 thru 7	(MSB) Reserved (LSB)							

Parameter	Value
PS: Parameters Savable	0 = Not supported
SPF: SubPage Format	0 = Mode page format
EPDC: Enable Precise Delivery Checking	0 = Not supported

Fibre Channel Port Control Page

TABLE 3-79 Fibre Channel Port Control Page (19h)

<table>
<tr><th rowspan="2">Byte</th><th colspan="8">Bit</th></tr>
<tr><th>7</th><th>6</th><th>5</th><th>4</th><th>3</th><th>2</th><th>1</th><th>0</th></tr>
<tr><td>0</td><td>PS</td><td>SPF (0)</td><td colspan="6">Page Code (19h)</td></tr>
<tr><td>1</td><td colspan="8">Page Length (06h)</td></tr>
<tr><td>2</td><td colspan="8">Reserved</td></tr>
<tr><td>3</td><td>DTFD</td><td>PLPB</td><td>DDIS</td><td>DLM</td><td>DSA</td><td>ALWI</td><td>DTIPE</td><td>DTOLI</td></tr>
<tr><td>4
thru
5</td><td colspan="8">(MSB)
Reserved
(LSB)</td></tr>
<tr><td>6</td><td colspan="5">Reserved</td><td colspan="3">RR_TOV units</td></tr>
<tr><td>7</td><td colspan="8">Resource Recovery Time Out Value (RR_TOV)</td></tr>
</table>

Parameter	Value
PS: Parameters Savable	0 = Not supported
SPF: SubPage Format	0 = Mode page format
DTFD: Disable Target Fabric Discovery	0 = Public Loop behavior supported
PLPB: Prevent Loop Port Bypass	0 = Not supported
DDIS: Disable Discovery	0 = Not supported
DLM: Disable Loop Master	0 = Not supported
DSA: Disable Soft Address	0 = Not supported
ALWI: Allow Login Without Loop Initialization	0 = Not supported
DTIPE: Disable Target Initiated Port Enable	0 = Not supported
DTOLI: Disable Target Originated Loop Initialization	0 = Not supported
RR_TOV units	101b = 10 second units
RR_TOV value	1Eh = 300 seconds

TapeAlert Page

TABLE 3-80 Mode Sense Tape Alert page

Byte	Bit 7	6	5	4	3	2	1	0
0	PS	SPF (0)	Page Code (1Ch)					
1	Page Length (0Ah)							
2	Perf	Reserved			DExcpt	Test	RSVD	LogErr
3	Reserved				MRIE (3h)			
4 thru 7	(MSB) Interval Timer (LSB)							
8 thru 11	(MSB) Report Counter / Test Flag Number (LSB)							

Parameter	Value
PS: Parameters Savable	0 = Not supported
SPF: SubPage Format	0 = Mode page format
Perf: Performance	0 = Informational exception operations that causes delays are acceptable
DExcpt: Disable Exception	1 = Target disables all information exception operations ignoring the MRIE field.
	In this mode the software must poll the TapeAlert Log page.
Test: Test operations	0 = Do not generate any false/test informational exception conditions
LogErr: Log Errors	0 = Logging of informational exception conditions is vendor–specific
MRIE	Method the drive uses to Report Informational Exception conditions.
	0h = No reporting of informational exception conditions
Interval Timer	Will always be 0
Report Counter/Test Flag Number	Will always be 0

Medium Configuration Page

TABLE 3-81 Mode Sense Medium Configuration Page

Byte	Bit 7	6	5	4	3	2	1	0
0	PS	SPF (0)	Page Code (1Dh)					
1	Page Length (1Eh)							
2	Reserved							WORMM
3	Reserved							
4	WORM Mode Label Restrictions							
5	WORM Mode Filemark Restrictions							
6 thru 31	(MSB) Reserved (LSB)							

Parameter	Value
PS: Parameters Savable	0 = Not supported
SPF: SubPage Format	0 = Mode page format
WORMM: WORM mode	0 = Normal mode
	1 = WORM (VolSafe) mode
WORM Mode Label Restrictions	1 = Some types of format labels may be overwritten
WORM Mode Filemark Restrictions	2 = All but one filemark at the EOD may be overwritten.

Medium Partition Mode Page

Mode sense page 11h, see , returns information about the current tape partitions on the mounted volume.

TABLE 3-82 Mode Sense Medium Partition mode page - T10000C and T10000D

Byte	Bit 7	6	5	4	3	2	1	0
0	PS (0)	SPF (0)	Page Code (11h)					
1	Page Length							
2	Maximum Additional Partitions							
3	Additional Partitions Defined							
4	FDP	SDP	IDP	PSM		POFM	CLEAR	ADDP
5	Medium Format Recognition							
6	Reserved				Partition Units			
7	Reserved							
8 thru 9	Partition 0 Size							
n-1 thru n	Partition Size							

Parameter	Value
Page Length	Additional bytes in this mode page 0Ah = Mode page with two partitions - T10000C 08h - 1Ah = determined by the number of partitions defined - T10000D
Maximum Additional Partitions	Maximum number of additional partitions supported 1 = Always one when tape loaded (T10000C) 9 = Always nine when tape loaded (T10000D)
Additional Partitions defined	Number of additional partitions 0 = No additional partitions, tape has one default partition 1 = One additional partition, tape has two partitions (T10000C) 1-9 = Additional partitions (T10000D)
FDP: Fixed Data Partitions	0 = Always zero
SDP: Select Data Partitions	0 = Always zero
IDP: Initiator Defined Partitions	Not used on mode sense command 0 = Tape not initiator partitioned 1 = Tape initiator partitioned

PSUM: Partition Size Unit of Measure	11b = $10^{(\text{partition units})}$ bytes
POFM: Partition On Format	1 = Partitioning occurs on subsequent Format Medium command
CLEAR: Logical erase	0 = Always zero
ADDP: Additional Partitions	0 = Always zero
Medium Format Recognition	03 = Logical unit capable of format and partition recognition
Partition Units	8h = 100 MB 9h = 1GB
Partition 0 Size	Size of partition 0 - T10000C 0000h bytes on non partitioned tape 005Dh bytes on partitioned tape Size of partition 0 - T10000D Number of bytes on non partitioned tape Number of bytes in partition 0 on a partitioned tape
Partition 1 Size	Size of partition 1 - T10000C 0000h bytes on non partitioned tape AF52h bytes on partitioned tape Size of partition 1 - T10000D
Partition n Size	Size of partition n - T10000D

Read/Write Control Page

Vendor unique page used to control writing to maximum tape capacity.

TABLE 3-83 Read/Write Control Page

Byte	Bit 7	6	5	4	3	2	1	0
0	PS	SPF (0)	Page Code (25h)					
1	Page Length (1Eh)							
2 thru 4	(MSB) Reserved (LSB)							
5	Reserved							AMC
6 thru 7	(MSB) Reserved (LSB)							
8	DFSA	LFA	Reserved					
9 thru 31	(MSB) Reserved (LSB)							

Parameter	Value
PS: Parameters Savable	0 = Not supported
SPF: SubPage Format	0 = Mode page format
AMC: Allow Maximum Capacity	0 = Constant capacity 1 = Maximum capacity Constant capacity is the advertised capacity of the media. Maximum capacity is the advertised capacity plus about 10% additional. **Note –** It is not recommended to use maximum capacity if a tape to tape copy will ever be attempted.
DFSA: Disable File Sync Accelerator	0 = FSA Enabled (default setting) 1 = Disable FSA File Sync Accelerator is a method that allows tape motions to continue when the host write rate drops below the tape speed
LFA: Large File Accelerator	0 = LFA disabled (default setting) 1 = LFA enabled

Note – Reserved bytes 2–4 and 6–31 are ignored.

Persistent Reserve In Command

The Persistent Reserve In command returns information about registered persistent reservation keys and the currently active persistent reservations.

TABLE 3-84 Persistent Reserve In Command

Byte	Bit 7	6	5	4	3	2	1	0
0	Operation Code (5Eh)							
1	Reserved			Service Action				
2 thru 6	(MSB) Reserved (LSB)							
7 thru 8	(MSB) Allocation Length (LSB)							
9	Control Byte							

Parameter	Value
Service Action	00h = Read Keys: Returns a list of all registered persistent reservation keys. 01h = Read Reservation: Returns information about the currently active persistent reservation. 02h = Report Capabilities: Returns information on persistent reservation features.
Allocation Length	Maximum length of parameter data to return

Read Keys Parameter Data

A Persistent Reserve In command with a Service Action of 00h (Read Keys) will return a list of the reservation keys for all currently registered initiators.

TABLE 3-85 Read Keys Parameter Data

Byte	Bit 7	6	5	4	3	2	1	0
0 thru 3	(MSB)			Generation				(LSB)
4 thru 7	(MSB)			Additional Length (n-7)				(LSB)
8 thru n	(MSB)			Reservation Keys (8 bytes each)				(LSB)

Parameter	Value
Generation	A 32-bit counter that is incriminated when persistent reservations are changed or registration keys are modified
Additional Length	Length of the Reservation Keys list. If 0, no Reservation Keys are active.
Reservation Keys	A list of all registered reservation keys known by the device

Read Reservations Parameter Data

A Persistent Reserve In command with a Service Action of 01h (Read Reservations) will return information about the currently active persistent reservation.

TABLE 3-86 Read Reservations Parameter Data

Byte	Bit 7	6	5	4	3	2	1	0
0 thru 3	(MSB)			Generation				(LSB)
4 thru 7	(MSB)			Additional Length (n-7)				(LSB)
8 thru n	(MSB)			Reservation descriptor(s) (see TABLE 3-87)				(LSB)

Read Reservations Descriptors

TABLE 3-87 Reservation Descriptors

Byte	Bit 7	6	5	4	3	2	1	0
0 thru 7	(MSB)			Reservation Key				(LSB)
8 thru 11	(MSB)			Scope-Specific Address				(LSB)
12				Reserved				
13		Scope				Type		
14 thru 15	(MSB)			Obsolete				(LSB)

Parameter	Value
Generation	A 32-bit counter that is incriminated when persistent reservations are changed or registration keys are modified.
Additional Length	Length of the Reservation Descriptors that follow. This will be 16 if a persistent reservation is active. If no persistent reservation is active, this field will be 0 and the following fields will not be returned.
Reservation Keys	Reservation key for the active Persistent Reservation.

Parameter	Value
Scope Specific Address	0 = Not supported
Scope	0 = Persistent Reservation is for the Logical Unit
Type	Persistent Reservation type
	3h = Exclusive Access for one initiator
	6h = Exclusive Access by all registered initiators

Report Capabilities Parameter Data

A Persistent Reserve In command with a Service Action of 02h (Report Capabilities) will return information about persistent reservation features.

TABLE 3-88 Report Capabilities Parameter Data

Byte	Bit 7	6	5	4	3	2	1	0
0 thru 1	(MSB) Length (0008h) (LSB)							
2	Reserved			CRH	SIP_C	ATP_C	RSVD	PTPL_C
3	TMV	Reserved						PTPL_A
4 thru 5	(MSB) Persistent Reservation Type Mask (see TABLE 3-89 on page 135) (LSB)							
6 thru 7	(MSB) Reserved (LSB)							

Parameter	Value
Length	Length in bytes of parameter data.
CRH: Compatible Reservation Handling	1= Supports exceptions to the SPC-2 Reserve and Release commands
	See TABLE 2-2 on page 33
SIP_C: Specify Initiator Ports Compatible	0 = Not supported
ATP_C: All Target Ports Capable	0 = Not supported
PTPL_C: Persist Through Power Loss Capable	0 = Not supported
TMV: Type Mask Valid	1 = Persistent reservation type mask valid
PTPL_A: Persist Through Power Loss Activated	0 = Not supported

TABLE 3-89 Persistent Reservation Type Mask Format

	Bit							
Byte	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
4	WR_EX_AR	EX_AC_RO	WR_EX_RO	Reserved	EX_AC	Reserved	WR_EX	Reserved
5	Reserved							EX_AC_AR

Parameter	Value
WR_EX_AR: Write Exclusive - All Registrants	0 = Not supported
EX_AC_RO: Exclusive Access - Registrants Only	1 = Supported
WR_EX_RO: Write Exclusive - Registrants Only	0 = Not supported
EX_AC: Excluisve Access	1 = Supported
WR_EX: Write Exclusive	0 = Not supported
EX_AC_AR: Exclusive Access- All Registrants	0 = Not supported

Persistent Reserve Out Command

The Persistent Reserve Out command is used to register Reservation Keys and create Persistent Reservations using these keys.

TABLE 3-90 Persistent Reserve Out Command

Byte	Bit 7	6	5	4	3	2	1	0
0	Operation Code (5Fh)							
1	Reserved			Service Action				
2	Scope				Type			
3 thru 6	(MSB) Reserved (LSB)							
7 thru 8	(MSB) Parameter List Length (18h) (LSB)							
9	Control Byte							

Parameter	Value
Service Action	Persistent Reserve function to perform
	00h = Register. Register a Reservation Key.
	01h = Reserve. Create a persistent reservation using a previously registered reservation key.
	02h = Release. Release a persistent reservation
	03h = Clear. Remove all reservation keys and reservations
	04h = Pre-empt. Take over a reservation previously made by another initiator
	05h = Pre-empt and Abort. Take over a reservation and abort commands
	06h = Register and Ignore existing key
Scope	00h = Logical Unit reservations
Type	Type of reservation to make or release
	03h = Exclusive Access 06h = Exclusive Access, registrants only
Parameter List Length	Length of parameter data sent (must be 18h)

Persistent Reserve Out Parameter List

TABLE 3-91 Persistent Reserve Out Parameter List

Byte	Bit 7	6	5	4	3	2	1	0
0 thru 7	(MSB) Reservation Key (LSB)							
8 thru 15	(MSB) Service Action Reservation Key (LSB)							
16 thru 19	(MSB) Obsolete (LSB)							
20	Reserved				SPEC_ I_PT	ALL_ TG_PT	Rsvd	APTPL
21	Reserved							
22 thru 23	(MSB) Obsolete (LSB)							

Parameter	Value
Reservation Key	Contains the currently registered key for the initiator. An unregistered initiator sets this field to zero when registering
Service Action Reservation Key	Contains the new Reservation Key for a Register, Pre-empt, or Pre-empt and Abort or Register and Ignore service action
SPEC_I_PT: Specify Initiator Ports	0 = Not supported
ALL_TG_PT: All Target Ports	0 = Not supported
APTPL: Active Persist Through Power Lost	0 = Reservations will be cleared when power is lost.

Registering a Reservation Key

An initiator must register a key before performing any other Persistent Reserve Out commands. To register a key, the initiator sends a Persistent Reserve Out command with the Service Action field set to Register (0h), and the Parameter List length set to 18h. The Scope and Type fields will be ignored. In the parameter data, the Reservation Key field is set to 0h, the Service Action Reservation Key is set to the desired key value and the APTPL bit to 0h. If the initiator is already registered, the key can be changed by sending the same command with the Reservation Key field set to the current reserved key.

A key may be registered without regard to whether one had been previously established by setting the Service Action field to Register and Ignore (06h).

Once an initiator has registered a key, it becomes a registered initiator and can perform other Persistent Reserve functions.

Creating a Persistent Reservation

To create a Persistent Reservation, a registered initiator sends a Persistent Reserve Out command with a Service Action field of Reserve (01h). The Scope field is set to 0, the Type field to Exclusive Access (03h) or Exclusive Access Registrants Only (06h), and the Parameter List Length to 18h. In the parameter data, the Reservation Key is set to the currently registered key for this initiator, the Service Action Reservation Key field is ignored, and the APTPL bit is set to zero.

A Type field of Exclusive Access will reserve the device for this initiator only. A Type field of Exclusive Access, Registrants Only will allow access by all registered initiators.

When a reservation of type Exclusive Access, Registrants Only is cleared, a unit attention condition is established for the initiators holding the reservation.

Releasing a Persistent Reservation

To release a Persistent Reservation, a registered initiator sends a Persistent Reserve Out command with a Service Action field of Release (02h). The Scope and Type fields must match those used when making the reservation. The Parameter List Length is set to 18h. In the parameter data, the Reservation Key is set to the currently registered key for this initiator, the Service Action Reservation Key field is ignored and the APTPL bit is set to zero.

When a reservation of type Exclusive Access, Registrants Only is released, a unit attention condition is established for the other registered initiators.

Clearing all Persistent Reservations and Keys

To clear all Persistent Reservations and key registrations, a registered initiator sends a Persistent Reserve Out command with a Service Action field of Clear (03h). The Scope and Type fields are ignored. The Parameter List Length is set to 18h. In the parameter data, the Reservation Key is set to the currently registered key for this initiator, the Service Action Reservation Key field is ignored and the APTPL bit is set to zero.

Clearing reservations should only be done in an error recovery situation.

Pre-empting Reservations Made by Another Initiator

A registered initiator can clear active reservations and registration keys by issuing a Persistent Reserve Out command. The Service Action field is set to Pre-empt, the Scope and Type fields are ignored. The Parameter List Length is set to 18h. In the parameter data, the Reservation Key is set to the currently registered key for this initiator. The Service Action Reservation Key field contains the registered key to be cleared. If the Service Action Reservation Key was used to make the currently active persistent reservation, the reservation is released.

If the Service Action field is set to Pre-empt and Abort instead of Pre-empt, all commands belonging to initiators who registered with the cleared key will be aborted.

When a reservation of type Exclusive Access, Registrants Only is Pre-empted, a unit attention condition is established for the Pre-empted initiators.

Prevent/Allow Medium Removal Command

The Prevent/Allow Medium Removal command enables and disables the unload switch. The switch is enabled unless this command is used.

TABLE 3-92 Prevent/Allow Medium Removal Command

Byte	Bit 7	6	5	4	3	2	1	0
0	Operation Code (1Eh)							
1 thru 3	(MSB) Reserved (LSB)							
4	Reserved						Prevent	
5	Control Byte							

Parameter	Value
Prevent	Prevent medium removal: 00 = Allow medium removal (enable switch) 01 = Prevent medium removal (disable switch)

Notes:

1. The tape does not have to be ready when a Prevent command is issued. The Prevent Medium Removal command disables only the unload switch. Unload commands from the host are still permitted.
2. Allow Medium Removal returns status to the host only after all buffered data is written on tape (the tape must be loaded and ready).
3. Medium removal is allowed only after all initiators that issued a Prevent have issued an Allow Medium Removal command.
4. A reset condition clears the prevent condition.

Read Command

The Read command transfers the next record or records from tape to the host. After successful completion of a Read Command, the tape is positioned after the last block read.

TABLE 3-93 Read Command

	Bit							
Byte	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	Operation Code (08h)							
1	Reserved						SILI	Fixed
2 thru 4	(MSB) Transfer Length (LSB)							
5	Control Byte							

Parameter	Value
SILI: Suppress Illegal Length Indication	0 = Check condition status is returned if the record length does not match Transfer Length. ILI (Illegal Length Indication) and Valid bits in sense data are set. In variable block mode, the Information bytes are set to the Transfer Length minus the actual record size. In fixed block mode, Information bytes are set to the Transfer Length minus the number of blocks transferred, not including the incorrect length block. 1 = Return Check Condition status only when the actual record length is larger than transfer length, and the Mode Sense block length field in not zero. **Note –** This option is not allowed if the fixed bit is 1.
Fixed	Indicates the block mode for data transfer: 0 = Variable block mode. Transfer Length is the number of bytes requested. 1 = Fixed block mode. Transfer Length is the number of blocks requested.
Transfer Length	Number of blocks or bytes requested.

Notes:

- Setting of the Fixed bit is only allowed if the fixed block length is not zero. In fixed block mode, the record size is specified by the block length. The Mode Sense command reports the fixed block length.

- If a filemark is encountered, Check Condition status is returned, the filemark and valid bits in sense data are set, and tape is positioned after the file mark. In variable block mode the Information bytes are set to transfer length. In fixed block mode, Information bytes are set to transfer length minus the actual number of blocks read, not counting the filemark.
- If end-of-data is encountered, Check Condition status is returned, the Sense Key is set to Blank Check, and the valid bit is set. Tape is positioned after the last valid record. Information Bytes are calculated as for a file mark.
- A Read past the logical end-of-tape (LEOT) does not generate a Check Condition. Reading into the physical end-of-tape (PEOT) generates Check Condition status with a sense key indicating Medium Error.
- After a Read command, the drive continues reading records into the buffer until the buffer is full or end of data or consecutive filemarks are found. Reading ahead allows faster response to subsequent Read commands.
- A transfer length of zero will not transfer any data, does not generate Check Condition status, and does not change the position of the tape.

Data Integrity Validation—Read Operations

During read operations when DIV mode is enabled, all Read commands should have a transfer length that includes both the user data and the appended 4 bytes of Protection Information.

> **Note –** Use the Mode Select command Page 0Ah, Subpage F0h, to enable the DIV mode.

When in DIV mode the T10000 A and B tape drives generate the PI data as it is being transferred from the tape drive to the controller data buffer.

On T10000C and T10000D tape drives the PI data is read from the media and transferred to the controller data buffer.

If an error occurs during Read operations, and the drive detects a miscompare, it reports it as a:

Check condition, with
Key = 04h (Hardware Error), and
ASC/ASCQ = 10 01h — Logical Block Guard Check Failed

Examples of when this may occur include:

- During the transfer of data from the tape drive to the controller data buffer, PI data is generated or checked as required.
- During the transfer of data from the controller data buffer to the Fibre Channel Port protocol chip, if it supports the current PI method.
- If the transfer length is more than the actual user data plus the PI bytes the tape drive returns all available user data and the PI bytes, reporting an Illegal Length Indicator (ILI).
- If the transfer length is less than the actual user data plus the PI bytes the tape drive checks the entire record in the controller data buffer against the PI bytes. Then reports a PI miscompare if necessary.

If there is no PI error then only the requested number of data bytes are returned to the Host, reporting of ILI and residuals as usual.

Read T10 PI (16) Command

The Read T10 PI (16) command (see TABLE 3-94) requests that the device server transfer the next record or records from tape to the host. After successful completion of a read operation, the tape is positioned after the last block read. Each block transferred includes user data and protection information.

The Read T10 PI (16) command shall only be processed if T10 PI Protection Method is enabled and the LBP_R control bit is set (see Control Data Protection Mode Page).

TABLE 3-94 Read T10 PI (16) Command

	Bit							
Byte	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	Operation Code (98h)							
1	GRDC	APPTC	REFTC	Reserved			SILI	FIXED
2	(MSB)							
3	EXPECTED INITIAL REFERENCE TAG							
4								
5								(LSB)
6	(MSB) EXPECTED APPLICATION TAG							
7								(LSB)
8	(MSB) APPLICATION TAG MASK							
9								(LSB)
10	(MSB							
11	TRANSFER LENGTH							
12								
13								(LSB)
14	Reserved							
15	CONTROL							

Parameter	Value
GRDC:	Guard Check 1 = Check the Guard field of the PI. 0 = Do not check the Guard field of the PI.
APPTC:	Application Tag Check 1 = Check the Application Tag field of the PI. 0 = Do not check the Application Tag field of the PI.

REFTC:	Reference Tag Check 1 = Check the Reference Tag field of the PI. 0 = Do not check the Reference Tag field of the PI.
SILI:	Suppress Illegal Length Indication = 0 Check condition status is returned if the record length does not match Transfer Length. ILI (Illegal Length Indication) and Valid bits in sense data are set. In variable block mode, the Information bytes are set to the Transfer Length minus the actual record size. In fixed block mode, Information bytes are set to the Transfer Length minus the number of blocks transferred, not including the incorrect length block. = 1 Return Check Condition status only when the actual record length is larger than transfer length, and the Mode Sense block length field in not zero. **Note –** This option is not allowed if the fixed bit is 1.
FIXED	Indicates the block mode for data transfer: = 0 Variable block mode. Transfer Length is the number of bytes requested. = 1 Fixed block mode. Transfer Length is the number of blocks requested.
EXPECTED INITIAL REFERENCE TAG:	= The first logical block reference tag. Subsequent reference tag fields will be plus one.
EXPECTED APPLICATION TAG:	= Each logical block application tag field is set by the application client.
APPLICATION TAG MASK:	= This field contains a value that is a bit mask for enabling the checking of the logical block application tag field.
TRANSFER LENGTH	Number of blocks or bytes requested.

Notes:

- Setting GRDC to 0 allows the customer read data to reside in the interface buffer with no protection! This operation is highly discouraged. The only valid setting of 0 is for diagnostic testing of Read T10PI error checking operations.
- If the device server detects a BLOCK APPLICATION TAG field set to FFFFh, then the device server disables checking of all other protection information for that associated protection information interval (single logical user data block) when reading from the medium.
- Setting of the Fixed bit is allowed only if the fixed block length is not zero. In fixed block mode, the record size is specified by the block length. The Mode Sense command reports the fixed block length.
- The physical T10PI record integrity can be verified with the Verify(6) and Verify(16) commands.

- See the Read Command description for additional notes.

Read Attribute Command

The Read Attribute command allows an application to read attribute values from medium auxiliary memory (MAM).

TABLE 3-95 Read Attribute Command

Byte	Bit 7	6	5	4	3	2	1	0
0	Operation Code (8Ch)							
1	Reserved			Service Action				
2 thru 4	(MSB) Restricted (see SMC-2) (LSB)							
5	Logical Volume Number							
6	Reserved							
7	Partition Number							
8 thru 9	(MSB) First Attribute Identifier (LSB)							
10 thru 13	(MSB) Allocation Length (LSB)							
14	Reserved							
15	Control Byte							

Parameter	Value / Description	
Service Action	00h	Attribute Values - Return attribute values.
	01h	Attribute List - Return a list of available attribute identifiers, identifiers that are not in the nonexistent state or unsupported state.
	02h	Logical Volume List - Return a list of logical volume numbers.
	03h	Partition List - Return partition numbers.
	05h	Return list of supported attributes
Logical Volume Number	Only volume 0, ignored for service action 02h	
Partition Number	Partition for requested attributes, ignored for service actions 02h, 03h	
First Attribute Identifier	Identifier of first attribute to be returned, ignored for service actions 01h, 02h, 03h, and 05h	
Allocation Length	Maximum length of attribute data to transfer	

Attribute Values Service Action

The Read Attribute command with the Service Action set to Attribute Values returns parameter data containing attribute values in ascending numerical order by attribute identifier value.

TABLE 3-96 Read Attribute with Attribute Values Service Action Parameter List Format

Byte	Bit 7	6	5	4	3	2	1	0
0 thru 3	(MSB) Available Data (n-3) (LSB)							
4	Attribute 0							
thru	. . .							
n	Attribute x							

Attribute List Service Action

The Read Attribute command with the Service Action set to Attribute List returns parameter data containing a list of available attributes.

TABLE 3-97 Read Attribute with Attribute List Service Action Parameter List Format

Byte	Bit 7	6	5	4	3	2	1	0
0 thru 3	(MSB) Available Data (n-3) (LSB)							
4 thru 5	Attribute Identifier 0							
n-1 thru n	. Attribute Identifier x .							

Logical Volume List Service Action

The Read Attribute command with the Service Action set to Logical Volume List returns parameter data containing a list of logical volume numbers.

TABLE 3-98 Read Attribute with Logical Volume List Service Action Parameter List Format

Byte	Bit 7	6	5	4	3	2	1	0
0 thru 1	(MSB) Available Data (0002h) (LSB)							
2	First logical Volume Number							
3	.Number of Logical Volumes Available.							

Partition List Service Action

The Read Attribute command with the Service Action set to Partition List returns parameter data identifying the number of partitions supported.

TABLE 3-99 Read Attribute with Partition List Service Action Parameter List Format

Byte	Bit 7	6	5	4	3	2	1	0
0 thru 1	(MSB) Available Data (0002h) (LSB)							
2	First Partition Number							
3	Number of Partitions Available							

Supported Attributes Service Action

The Read Attribute command with the Service Action set to Supported Attributes returns parameter data containing a list of supported attributes.

TABLE 3-100 Read Attribute with Supported Attributes Service Action Parameter List Format

Byte	Bit 7	6	5	4	3	2	1	0
0 thru 3	(MSB) Available Data (n-3) (LSB)							
4 thru 5	Attribute Identifier 0							
n-1 thru n	. Attribute Identifier x .							

Medium Auxiliary Memory Attributes

The format of each medium auxiliary memory attribute transferred by the Write Attribute and Read Attribute commands has the format defined in TABLE 3-103.

Device type attributes are maintained by the T10000 tape drive and cannot be written to MAM using the Write Attribute command.

TABLE 3-101 Device Type Attributes Supported

Attribute Identifier	Name	Attribute Length (in bytes)	Format
0009h	Volume Change Reference	8	Binary
0224h	Logical Position of First Encrypted Block	8	Binary

Host type attributes are maintained by the application. Host attributes can only be stored on a partitioned tape (more than one partition).

TABLE 3-102 Host Type Attributes Supported

Attribute Identifier	Name	Attribute Length (in bytes)	Format
0800h	Application Vendor	8	ASCII
0801h	Application Name	32	ASCII
0802h	Application Version	8	ASCII
0803h	User Medium Text Label	160	Text
0804h	Date And Time Last Written	12	ASCII
0805h	Text Localization Identifier	1	Binary
0806h	Barcode	32	ASCII
0807h	Owning Host Textual Name	80	Text
0808h	Media Pool	160	Text
0809h	Partition User Text Label	16	ASCII
080Ah	Load/Unload At Partition	1	Binary
080Bh	Application Format Version	16	ASCII
080Ch	Volume Coherency Information	70	Binary
1400h - 17FFh	Vendor Specific	Vendor Specific	Vendor Specific

Medium Auxiliary Memory Attribute Format

Each medium auxiliary memory (MAM) attribute is communicated between the application client and device server in the following format.

TABLE 3-103 Medium Auxiliary Memory Attribute Format

Byte	Bit 7	6	5	4	3	2	1	0
0 thru 1	(MSB) Attribute Identifier (LSB)							
2	Read Only	Reserved					Format	
3 thru 4	(MSB) Attribute Length (n-4) (LSB)							
5 thru n	(MSB) Attribute Value (LSB)							

Parameter	Value/Description
Attribute Identifier	Contains a code value that identifies the attribute.
Read Only	Indicates whether the attribute is in the read only state. 0 = The attribute is in the read/write state 1 = The attribute is in the read only state
Format	Specifies the format of the data in the Attribute Value field 00b Binary Contains binary data. 01b ASCII Contains left-aligned ASCII data. 10b Text Contains textual data. The character set is described in the Text Localization Identifier attribute. 11b Reserved
Attribute Length	Specifies the length in bytes of the Attribute value field.
Attribute Value	Contains the current value, for the Read Attribute command

Attribute List—Service Action

Returns parameter data contains the attribute identifiers for the attributes that are not in the unsupported state and not in the nonexistent state in the specified partition and volume number.

TABLE 3-104 Read Attribute with Attribute List—Service Action Format

Byte	Bit 7	6	5	4	3	2	1	0
0 thru 3	(MSB) Available Data (n-3) (LSB)							
	Attribute Identifiers							
4 thru 5	(MSB) Attribute Identifier 0 (LSB)							
	. . .							
n-1 thru n	(MSB) Attribute Identifier x (LSB)							

Parameter	Value
Available Data	Contains the number of bytes of attribute identifiers in the parameter list
Attribute Identifier	Returns each attribute that is not in the unsupported state and not in the nonexistent state in the specified partition and volume number = 0x0224

Volume List—Service Action

Returns parameter data identifying the supported number of volumes.

The contents of Volume Number, Partition Number, and First Attribute Identifier fields in the CDB shall be ignored.

TABLE 3-105 Read Attribute with Volume List—Service Action Format

	Bit							
Byte	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0 thru 1	(MSB) Available Data (0002h) (LSB)							
2	First Volume Number							
3	Number of Volumes Available							

Parameter	Value
Available Data	Contains the number two
First Volume Number	Indicates the first volume available = 0
Number of Volumes Available	Indicates the number of volumes available = 1

Partition List—Service Action

Returns parameter data identifying the supported number of partitions supported in the specified volume.

The contents of Partition Number, and First Attribute Identifier fields in the CDB shall be ignored.

TABLE 3-106 Read Attribute with Partition List—Service Action Format

Byte	Bit 7	6	5	4	3	2	1	0
0 thru 1	(MSB) Available Data (0002h) (LSB)							
2	First Partition Number							
3	Number of Partitions Available							

Parameter	Value
Available Data	Contains the number two
First Partition Number	Indicates the first partition number on the specified volume = 0
Number of Partitions Available	Indicates the number of partitions available on the specified volume = 1

Read Block Limits Command

The Read Block Limits command establishes the longest and shortest record size supported by the tape drive. This command returns six bytes of data.

- When the DIV feature is not enabled the Maximum Block Length reported by the Read Block Limits command is 2,097,152 bytes.
- When the DIV feature is enabled the Maximum Block Length reported by the Read Block Limits command is increased by 4 bytes to account for the extra bytes of PI data (2,097,156 bytes).

TABLE 3-107 Read Block Limits Command

Byte	Bit 7	6	5	4	3	2	1	0
0	Operation Code (05h)							
1 thru 4	(MSB) Reserved (LSB)							
5	Control Byte							

Read Block Limits Data

TABLE 3-108 Read Block Limits Data

Byte	Bit 7	6	5	4	3	2	1	0
0	Reserved			Granularity				
1 thru 3	(MSB) Maximum Block Length (LSB)							
4 thru 5	(MSB) Minimum Block Length (LSB)							

Parameter	Value
Granularity	0
Maximum block length	2,097,152 bytes (standard) 2,097,156 bytes (with the DIV feature)
Minimum block length	1 byte

Read Buffer Command

The Read Buffer Command retrieves trace dump data. Any buffered write data and filemarks are written on the tape *before* this operation starts.

TABLE 3-109 Read Buffer Command

<table>
<tr><th rowspan="2">Byte</th><th colspan="8">Bit</th></tr>
<tr><th>7</th><th>6</th><th>5</th><th>4</th><th>3</th><th>2</th><th>1</th><th>0</th></tr>
<tr><td>0</td><td colspan="8">Operation Code (3Ch)</td></tr>
<tr><td>1</td><td colspan="3">Reserved</td><td colspan="5">Mode</td></tr>
<tr><td>2</td><td colspan="8">Buffer ID</td></tr>
<tr><td>3
thru
5</td><td colspan="8">(MSB)
Buffer Offset
(LSB)</td></tr>
<tr><td>6
thru
8</td><td colspan="8">(MSB)
Allocation Length
(LSB)</td></tr>
<tr><td>9</td><td colspan="2">Vendor–specific</td><td colspan="4">Reserved</td><td>Flag</td><td>Link</td></tr>
</table>

Parameter	Value
Mode	Read buffer mode 01h = Vendor-specific 03h = Descriptor 0Ah = Echo buffer 0Bh = Echo buffer descriptor
Buffer ID	FAh = MIR position data FCh = MIR performance data (not on T10000C and T10000D) FDh = Permanent error trace data FEh = Event log data (not on T10000C) FFh = Dump buffer
Buffer Offset	Offset from start of buffer (this field is ignored, except for Mode 0Ah on T10000D and newer drives)
Allocation Length	Maximum length of dump data to transfer

Notes:

- The tape drive must be unloaded when reading dump, permanent error trace, or event log data. The minimum allocation length is 4096 bytes.
- Multiple Read Buffer commands may be required to read the entire contents of a particular buffer. Blocks of data are transferred in sequential order. Blocks of data may be truncated, this does not signify the end of the transfer, continuing transfer data blocks until Blank Check is returned. All Read Buffer commands needed to read a complete buffer must use the same allocation length. The sequence of read buffer commands required to read a complete buffer should continue uninterrupted until a sense key of Blank Check is returned.

- The dump buffer may contain multiple dumps up to a maximum of 12 MB of data.
- The maximum amount of permanent error trace data or event log data is 524KB.
- If no data remains to be transferred, Check Condition status is returned. The sense key is set to Blank Check with the valid bit set.

TABLE 3-110 Read Buffer Descriptor

<table>
<tr><th rowspan="2">Byte</th><th colspan="8">Bit</th></tr>
<tr><th>7</th><th>6</th><th>5</th><th>4</th><th>3</th><th>2</th><th>1</th><th>0</th></tr>
<tr><td>0</td><td colspan="8">Offset Boundary</td></tr>
<tr><td>1
thru
2</td><td colspan="8">(MSB)
Buffer Capacity
(LSB)</td></tr>
</table>

Parameter	Value
Offset Boundary	FFh = 0 is the only supported offset boundary
Buffer Capacity	Size of selected buffer in bytes

TABLE 3-111 Echo Buffer Descriptor

<table>
<tr><th rowspan="2">Byte</th><th colspan="8">Bit</th></tr>
<tr><th>7</th><th>6</th><th>5</th><th>4</th><th>3</th><th>2</th><th>1</th><th>0</th></tr>
<tr><td>0</td><td colspan="7">Reserved</td><td>EBOS</td></tr>
<tr><td>1</td><td colspan="8">(MSB) Reserved</td></tr>
<tr><td>2</td><td colspan="3">Reserved (LSB)</td><td colspan="5">(MSB) Buffer Capacity</td></tr>
<tr><td>3</td><td colspan="8">Buffer Capacity (LSB)</td></tr>
</table>

Parameter	Value
Buffer Capacity	Size of Echo Buffer in the bytes aligned to a four byte boundary. Maximum size is 4096 bytes
EBOS: Echo Buffer Overwritten Supported	1 = Supported. Illegal Request, echo buffer overwritten additional sense code is returned if data was not previously written by the same initiator.

Read Media Serial Number Command

The Read Media Serial Number Command returns the serial number of the currently mounted tape.

TABLE 3-112 Read Media Serial Number Command

Byte	Bit 7	6	5	4	3	2	1	0
0	Operation Code (ABh)							
1	Reserved			Service Action (01h)				
2 thru 5	(MSB) Reserved (LSB)							
6 thru 9	(MSB) Allocation Length (LSB)							
10	Reserved							
11	Control							

Parameter	Value
Allocation Length	Maximum length of data to transfer

Read Media Serial Number Parameter Data

TABLE 3-113 Read Media Serial Number Parameter Data

Byte	Bit 7	6	5	4	3	2	1	0
0 thru 3	(MSB) Media Serial Number Length (4n-4) (LSB)							
4 n	(MSB) Media Serial Number (LSB)							

Parameter	Value
Media Serial Number Length	Number of bytes modulo four
Media Serial Number	Vendor specific

Read Position Command

The Read Position command returns information about the current logical and physical block address of the tape. This command returns 20 or 32 bytes of data depending on the service action.

TABLE 3-114 Read Position Command

Byte	Bit 7	6	5	4	3	2	1	0
0	Operation Code (34h)							
1	Reserved			Service Action				
2 thru 6	(MSB) Reserved (LSB)							
7 thru 8	(MSB) Allocation Length							
9	PPI	Control Byte						

Parameter	Value
Service Action	00h = Return short form data (20 bytes)
	01h = Return Short form data
	02h = Return physical position indicator data (32 bytes) if PPI = 1
	06h = Return long form data
Allocation Length	0000h = 20 or 32 bytes returned depending on service action
PPI: Physical Position Indicator	0 = Return Normal read position
	1 = Return Physical Position Indicator data

TABLE 3-115 Read Position Data - Short Form

Byte	Bit 7	6	5	4	3	2	1	0
0	BOP	EOP	BCU	BYCU	RSVD	LOLU	PERR	RSVD
1	Partition Number							
2 thru 3	(MSB) Reserved (LSB)							
4 thru 7	(MSB) First Logical Object Location (LSB)							
8 thru 11	(MSB) Last Logical Object Location (LSB)							
12	Reserved							
13 thru 15	(MSB) Number of Logical Objects in Object Buffer (LSB)							
16 thru 19	(MSB) Number of Bytes in Object Buffer (LSB)							

Parameter	Value
BOP: Beginning-of-Partition	0 = Tape is not positioned at BOP
	1 = Tape is positioned at BOP
EOP: End-of-Partition:	0 = Tape is not past LEOT
	1 = Tape is past LEOT
LOCU: Logical object count unknown	0 = Number of logical objects in object buffer is valid
	1 = Number of logical objects in object buffer is not valid
BYCU: Byte Count Unknown	0 = Number of bytes in object buffer is valid
	1 = Number of bytes in object buffer is not valid
LOLU: Logical object location unknown	0 = First logical object location, last logical object location or partition number are valid
	1 = First logical object location, last logical object location and partition number are not valid
PERR: Position Error	0 = Location fields are valid
	1 = Location fields have overflowed and are invalid

Parameter	Value
BPEW: Beyond Programmable Early Warning	0 = not implemented
Partition	Partition number of current logical position
First Logical Object Location	Address of the next block in the buffer assuming the next host operation is a write.
Last Logical Object Location	Address of the next block on tape assuming the next operation is a write.

TABLE 3-116 Read Position Data - Long Form

Byte	Bit 7	6	5	4	3	2	1	0
0	BOP	EOP	Reserved		MPU	LONU	Rsvd	BPEW
1 thru 3	(MSB)			Reserved				(LSB)
4 thru 7	(MSB)			Partition Number				(LSB)
8 thru 15	(MSB)			Logical Object Number				(LSB)
16 thru 23	(MSB)			Logical File Identifier				(LSB)
24 thru 31	(MSB)			Obsolete				(LSB)

Parameter	Value
BOP: Beginning-of-Partition	0 = Tape is not positioned at BOP. 1 = Tape is positioned at BOP.
EOP: End-of-Partition	0 = Tape is not past LEOT. 1 = Tape is past LEOT.
MPU: Mark Position Unknown	0 = Logical file identifier is valid. 1 = Logical file identifier is not known.
LONU: Logical Object Number Unknown	0 = Logical object number and partition number are valid. 1 = Logical object number and partition number are not valid
BPEW: Beyond Programmable Early Warning	0 = not implemented
Partition Number	Partition number of current logical position
Logical Object Number	Block ID of current logical position
Logical File Identifier	Number of filemarks between BOP and the current logical position

Physical Position Indicator Data

TABLE 3-117 Physical Position Indicator Data

Byte	Bit 7	6	5	4	3	2	1	0
0	Wrap							
1	Section							
2	Track Density				Length			
3	Section Layout							
4	Cartridge Type							
5	Last Tape Speed				Next Tape Speed			
6 thru 7	(MSB) Partition Size							(LSB)
8 thru 13	(MSB) Host Side ID							(LSB)
14 thru 19	(MSB) Device Side ID							(LSB)
20 thru 23	(MSB) Matrix Count							(LSB)
24 thru 27	(MSB) Space Remaining							(LSB)
28 thru 31	(MSB) Servo Position							(LSB)

Parameter	Value
Wrap	Wrap number
Section	Section number
Track Density	Number of tracks
	1h = 768 tracks
	2h = 1,152 tracks
	3h = 3,584 tracks
	4h = 4,608 tracks

Parameter	Value
Length	Tape length
	2h = Standard cartridge
	4h = Sport cartridge
Section Layout	Number of sections
	01 = One section
Cartridge Type	10h = Data tape
	20h = Code load tape
	40h = Dump tape
Last Tape Speed	1h = Lowest speed
	2h = Next lowest speed
	3h = Medium speed
	4h = Next highest speed
	5h = Highest speed
Next Tape Speed	1h = Lowest speed
	2h = Next lowest speed
	3h = Medium speed
	4h = Next highest speed
	5h = Highest speed
Partition Size	Capacity in Gigabytes (GB)
Host Side ID	Next block to be written or read from the drive buffer
Device Side ID	Next block to be written or read from the tape
Matrix Count	Number of matrices down the tape
Space Remaining	Space remaining on the tape in 4K byte blocks
Servo Position	Longitudinal position

Receive Diagnostic Results

The receive diagnostic results command returns diagnostic information.

TABLE 3-118 Receive Diagnostic Results Command

Byte	Bit 7	6	5	4	3	2	1	0
0	Operation Code (1Ch)							
1	Reserved							PCV
2	Page Code							
3 thru 4	(MSB) Allocation Length (LSB)							
5	Control Byte							

Parameter	Value
PCV: Page Code Valid	0 = Return data defined by recent Send Diagnostic Command. 1 = Return data defined by page code
Page Code: Diagnostic data page to return	00 = List of supported pages C0 = Diagnostics results page
Allocation Length	Maximum Allowed Length in Bytes of Returned Data.

Receive Diagnostic Results Page Format

TABLE 3-119 Receive Diagnostic Results Page Format

Byte	Bit 7	6	5	4	3	2	1	0
0	Page Code							
1	Reserved							
2 thru 3	(MSB) Page Length (n-3) (LSB)							
4 thru n	(MSB) Diagnostic Parameter (LSB)							

Parameter	Value
Page Code	Identifies Diagnostic Page

Note – The page length reflects the absolute length of the page, and is not adjusted because of the allocation length.

Receive Recommended Access Order Command

The Receive Recommended Access Order (RRAO) command is used to retrieve a RAO list of User Data Segments. The RRAO command is defined by an operation code and Service Action.

TABLE 3-120 Receive Recommended Access Order command

Byte	Bit 7	6	5	4	3	2	1	0
0	Operation Code(A3H)							
1	UDS_Limits	Reserved		Service Action (11h)				
2 thru 5	(MSB) RAO List Offset (LSB)							
6 thru 9	(MSB) Allocation Length (LSB)							
10	Reserved					UDS_Type		
11	Control Byte							

UDS Limits: 0 = RAO list returned

1 = UDS Limits page returned

RRAO List Offset: Offset into RAO list to begin returning data, must be 0 or multiple of 4

Allocation Length: Maximum number of bytes that may be returned

UDS Type: Format of User Data Descriptor used in calculating max number of UDS's supported if UDS

Limits bit is set to one. Ignored if UDS Limits bit is set to zero

TABLE 3-121 UDS Limits Page

Byte	Bit 7	6	5	4	3	2	1	0
0 thru 1	(MSB) Maximum UDS Supported (LSB)							
2 thru 3	(MSB) Maximum UDS Size (LSB)							

Maximum UDS Supported: Maximum number of User Data Segments supported for the UDS Type specified in the RRAO command

Maximum UDS Size: Maximum size of the UDS descriptor for the UDS Type specified in the RRAO command

TABLE 3-122 RAO List

Byte	Bit 7	6	5	4	3	2	1	0
0	Reserved					RAO Process		
1	Reserved					Status		
2 thru 3	(MSB) Reserved (LSB)							
4 thru 7	(MSB) RAO Descriptor List Length (n -7) (LSB)							
RAO Descriptor List								
8 thru x	(MSB) User Data Segment descriptor (first) (LSB)							
	. . .							
y thru n	(MSB) User Data Segment descriptor (last)							

Parameter	Value
RAO Process	Process used to generate the RAO list
Status	Status of the RAO list 000b = RAO list was never generated or was cleared by a GRAO command. RAO descriptor list length will be zero. 001b = RAO list contains a User Data Descriptor for each UDS in the GRAO parameter list. List was generated using the process specified in the RAO Process field.
RAO Descriptor List Length	Number of bytes to follow

TABLE 3-123 User Data Segment Descriptor

Byte	Bit 7	6	5	4	3	2	1	0
0 thru 1	(MSB) UDS Descriptor Length (n-1) (LSB)							
2	Reserved							
3	Reserved							
4	Estimated Locate Time To UDS							
5 thru 14	UDS Name							
15	Partition Number							
16 thru 23	(MSB) Beginning Logical Object Identifier (LSB)							
24 thru 31	(MSB) Ending Logical Object Identifier (LSB)							
Additional Information Descriptors								

Parameter	Value
UDS Descriptor Length:	Number of bytes to follow
Estimated Locate Time to UDS:	Estimated time to locate as defined by the RAO Process.
UDS Name:	Name of this User Data Segment in the GRAO parameter list.
Partition Number:	Partition number in which this User Data Segment is located
Beginning Logical Object Identifier:	Logical object identifier of the beginning logical object in this User Data Descriptor
Ending Logical Object Identifier:	Logical object identifier of the last logical object in this User Data Descriptor

Release Unit Command

The Release Unit command cancels reservations made by the Reserve Unit Command. If the unit is reserved by another initiator, good status is returned, but the unit is not released. If the unit is not currently reserved, good status is also returned.

TABLE 3-124 Release Unit—6 Byte Command

Byte	Bit							
	7	6	5	4	3	2	1	0
0	Operation Code (17h)							
1	Reserved			Obsolete				
2	Reservation Identification							
3 thru 4	(MSB) Reserved (LSB)							
5	Control Byte							

TABLE 3-125 Release Unit—10 Byte Command

Byte	Bit							
	7	6	5	4	3	2	1	0
0	Operation Code (57h)							
1	Reserved			3rd Pty	Reserved		LongID	Obsolete
2	Reservation Identification							
3	Third Party Device ID							
4 thru 6	(MSB) Reserved (LSB)							
7 thru 8	(MSB) Parameter List Length (LSB)							
9	Control Byte							

Parameter	Value
3rd Party: Third party reservations	0 = Cancel reservations for current host (not supported)
Long ID: SCSI ID for third party release	0 = Not supported
Reservation Identification	0 = Not supported
Third Party Device ID	0 = Not supported
Parameter List Length	0 = Not supported

Report Density Support Command

The Report Density command returns information about the density codes and recording formats.

TABLE 3-126 Report Density Support Command

Byte	Bit 7	6	5	4	3	2	1	0
0	Operation Code (44h)							
1	Reserved							Media
2 thru 6	(MSB) Reserved (LSB)							
7 thru 8	(MSB) Allocation Length (LSB)							
9	Control Byte							

Parameter	Value
Media	0 = Report densities supported by this tape drive
	1 = Report densities supported by currently mounted media
Allocation Length	Maximum size of data returned

Note – If the media bit is set to one, the tape drive must have a tape loaded.

The Report Density Support command with the Media bit set to zero returns three density support data block descriptors on the T10000C and four density support data block descriptors on the T100000D drive. These are the densities supported by the tape drive. When the Media bit is set to one the densities supported by the loaded cartridge are reported. A Type 1 cartridge supports densities 4Ah and 4Bh on both T10000C and T10000D drives. A Type 2 cartridge supports density 4Ch on a T10000C drive. A Type 2 cartridge supports densities 4Ch and 4Dh on a T10000D drive.

Report Density Support Data

TABLE 3-127 Density Support Header

Byte	Bit 7	6	5	4	3	2	1	0
0 thru 1	(MSB) Available Density Support Length (LSB)							
2 thru 3	(MSB) Reserved (LSB)							
4 thru n	(MSB) Density Support Block Descriptor (LSB)							

Parameter	Value
Available Density Support Length	**Control data that follows.** 36h = One density support block returned for T10000A 6Ah = Two density support blocks returned for T10000B 9Eh = Three density support blocks returned for T10000C D2h = Four density support blocks returned for T10000D
Density Support Block Descriptor	

Density Support Block Descriptor

TABLE 3-128 Density Support Data Block Descriptor

Byte	Bit 7	6	5	4	3	2	1	0
0	Primary Density Code							
1	Secondary Density Code							
2	WRTOK	DUP	Deflt	Reserved				
3 thru 4	(MSB) Reserved (LSB)							
5 thru 7	(MSB) Bits per MM (LSB)							
8 thru 9	(MSB) Media Width (LSB)							
10 thru 11	(MSB) Tracks (LSB)							
12 thru 15	(MSB) Capacity (LSB)							
16 thru 23	(MSB) Assigning Organizations (LSB)							
24 thru 31	(MSB) Density Name (LSB)							
32 thru 51	(MSB) Description (LSB)							

Parameter	Value
Primary Density Code	4Ah = Density code for T10000A 4Bh = Density code for T10000B 4Ch = Density code for T10000C 4Dh = Density code for T10000D

Parameter	Value
Secondary Density Code	4Ah = Primary density code, no secondary density code for T100000A 4Bh = Primary density code, no secondary density code for T100000B 4Ch = Primary density code, no secondary density code for T10000C 4Dh = Primary density code, no secondary density code for T10000D
WRTOK: Write Support	0 = Writes not permitted with this density code 1 = Drive is capable of writing at this density
DUP Duplicate Density Support Block	0 = Only 1 density support data block for this density code
Deflt: Default density code	1 = This is the default density code
Bits Per MM	Bit Density per Millimeter for This Recording Format 0 = Not applicable
Media Width	Width of Media in Tenths of a Millimeter 127(7Fh) = 1/2 inch
Tracks	Number of tracks with this recording format 768 (300h) tracks for T10000A tape drive 1,152 (480h) tracks for T10000B tape drive 3,584 (E00h) tracks for T10000C tape drive 4,608 (1200h) tracks for T10000D tape drive
Capacity	Approximate capacity of the media in 1,000,000 byte measurement units 500,000 (7A120h) = T10000A cartridge tape capacity 120,000 (1D4C0) = T10000A Sport cartridge tape capacity 1,000,000 (F4240h) = T10000B cartridge tape capacity 240,000 (3A980h) = T10000B Sport cartridge tape capacity 5,000,000 (4C4b40h) = T10000C cartridge tape capacity 1,000,000 (F4240h) = T10000C Sport cartridge tape capacity 8,000,000 (7A1200h) = T10000D cartridge tape capacity 1,600,000 (186A00h) = T10000D Sport cartridge tape capacity
Assigning Organization	ASCII organization defining this recording format STK = Format defined by StorageTek, Sun Microsystems

Parameter	Value
Density Name	ASCII name for this recording format T1 – 500 = T10000A recording format TS – 120 = T10000A Sport tape T1 – 1000 = T10000B recording format TS – 240 = T10000B Sport tape T2 – 5000 = T10000C recording format TT – 1000 = T10000C Sport tape T2 - 8000 = T10000D recording format TT - 1600 = T10000D Sport tape
Description	ASCII description for this recording format T1 – 500 GB = T10000A recording format TS – 120 GB = T10000A Sport tape T1 – 1000 GB = T10000B recording format TS – 240 GB = T10000B Sport tape T2 – 5000 GB = T10000C recording format TT – 1000 GB = T10000C Sport tape format T2 - 8000 GB = T10000D recording format TT - 1600 GB = T10000D Sport tape

Report LUNs Command

The Report LUNs command reports the address of the available logical units.

TABLE 3-129 Report LUNs Command

Byte	Bit 7	6	5	4	3	2	1	0
0	Operation Code (A0h)							
1 thru 5	(MSB) Reserved (LSB)							
6 thru 9	(MSB) Allocation Length (LSB)							
10	Reserved							
11	Control Byte							

Parameter	Value
Allocation Length	Maximum allowed length in bytes of returned data.

Report LUNs Parameter Data

TABLE 3-130 Report LUNs Parameter Data

Byte	Bit 7	6	5	4	3	2	1	0
0 thru 3	(MSB) LUN List Length (8h) (LSB)							
4 thru 7	(MSB) Reserved (LSB)							
8 thru 15	(MSB) LUN Address (LSB)							

Parameter	Value
LUN Address	Address of supported logical unit.

Report Supported Operation Codes Command

The Report Supported Operation Codes command returns information about the commands supported by the tape drive.

TABLE 3-131 Report Supported Operation Codes Command

Byte	Bit 7	6	5	4	3	2	1	0
0	Operation Code (A3h)							
1	Reserved			Service Action (0Ch)				
2	RCTD	Reserved				Reporting Options		
3	Requested Operation Code							
4 thru 5	Requested Service Action							
6 thru 9	(MSB) Allocation Length (LSB)							
10	Reserved							
11	Control Byte							

Parameter	Value
RCTD: Return Command Timeouts Descriptor	0 = Do not return timeout descriptor. 1 = Return a timeout descriptor with each command descriptor.
Reporting options	000b = Return a list of all operation codes and service actions supported by the tape drive. 001b = Return command support data for the requested operation code. 010b = Return command support data for the requested operation code and service action.
Requested operation code	Operation code for reporting options 1 and 2.
Requested service action	Service action for reporting option 2.
Allocation length	Maximum length of data to return.

All_Commands Parameter Data Format

The Report Supported Operation Codes All_Commands Parameter Data Format begins with a four-byte header that contains the length in bytes of the parameter data followed by a list of supported commands.

The list of command descriptors contains all commands supported by the logical unit.

TABLE 3-132 All_Commands Parameter Data

Byte	Bit 7	6	5	4	3	2	1	0
0 thru 3	(MSB) Command Data Length (n-3) (LSB)							
Command Descriptors								
4	(MSB) Command Descriptor 0 (see TABLE 3-133) (LSB)							
thru	. . .							
n	(MSB) Command Descriptor x (see TABLE 3-133) (LSB)							

The Command Data Length field indicates the length in bytes of the command descriptor list.

Each command descriptor (TABLE 3-133) contains information about a single supported command CDB.

TABLE 3-133 Command Descriptor Format

Byte	Bit 7	6	5	4	3	2	1	0
0	Operation Code							
1	Reserved							
2 thru 3	(MSB) Service Action (LSB)							
4	Reserved							
5	Reserved						CTDP	SERV ACTV
6 thru 7	(MSB) CDB Length (LSB)							
8 thru 19	(MSB) Command Timeouts Descriptor (see TABLE 3-135 on page 182) (LSB)							

Parameter	Value
Service Action	Contains a supported service action for the operation code. If the operation code does not have a service action, this field is set to 00h.
CTDP: Command Timeouts Descriptor Present	Command Timeouts Descriptor Present 0 = Indicates that the command timeouts descriptor is not included in this command descriptor 1 = Indicates that the command timeouts descriptor (see TABLE 3-135 on page 182) is included in this command descriptor
SERVACTV: Service Action Valid	Service Action Valid 0 = Indicates the operation code does not have service actions and the Service Action field contents are reserved 1 = Indicates the operation code has service actions and the contents of the Service Action field are valid
CDB Length: Command Data Block Length	Command Data Block Length Contains the length of the command CDB in bytes for the operation code, and if the SERVACTV bit is set, for the Service Action.

One_Command Parameter Data Format

The Report Supported Operation Codes One_Command Parameter Data Format contains information and a usage map for bits in the CDB for the command and service action field.

TABLE 3-134 One_Command Parameter Data

Byte	Bit 7	6	5	4	3	2	1	0
0	Reserved							
1	CTDP	Reserved				Support		
2 thru 3	(MSB) CDB Size (n-3) (LSB)							
4 thru n	(MSB) CDB Usage Data (LSB)							
n+1 thru n+12	(MSB) Command Timeouts Descriptor (see TABLE 3-135 on page 182) (LSB)							

Parameter	Value	
CTDP: Command Timeouts Descriptor Present	Command Timeouts Descriptor Present 0 = Indicates the command timeouts descriptor is not included in the parameter data 1 = Indicates the command timeouts descriptor is included in the parameter data (see TABLE 3-135 on page 182)	
Support	000b	Data about the requested SCSI command is not currently available. All data after byte 1 is not valid. A subsequent request for command support data may be successful.
	001b	The device server does not support the requested command. All data after byte 1 is undefined.
	010b	Reserved
	011b	The device server supports the requested command in conformance with a SCSI standard. The parameter data format conforms to the definition in TABLE 3-134.
	100b	Reserved
	101b	The device server supports the requested command in a vendor specific manner. The parameter data format conforms to the definition in TABLE 3-134.
	110b to 111b	Reserved

<table>
<tr><th>Parameter</th><th>Value</th></tr>
<tr><td>CDB Size</td><td>Contains the size of the CDB Usage Data field in the parameter data, and the number of bytes in the CDB for command being queried.

For example, the command specified by the Reporting Options, Requested Operation Code, and Requested Service Action fields in the Report Supported Operation Codes CDB.</td></tr>
<tr><td>CDB Usage Data</td><td>Contains information about the CDB for the command being queried.

The First byte of the field contains the operation code for the command. If the command being queried contains a service action, then that service action code is placed in the Usage Data field in the same location as the Service Action field of the command CDB.

All other bytes of the Usage Data field contains a usage map for bits in the CDB for the command being queried.

Usage Map:
The bits in the usage map have a one-for-one correspondence to the CDB for the command being queried.

• If the device server evaluates a bit in the CDB for the command being queried, the usage map shall contain a one in the corresponding bit position.

• If any bit representing part of a field is returned as one, all bits for the field shall be returned as one.

• If the device server ignores or treats as reserved a bit in the CDB for the command being queried, the usage map shall contain a zero in the corresponding bit position. The usage map bits for a given CDB field all shall have the same value.</td></tr>
</table>

Command Timeouts Descriptor

The Command Timeouts Descriptor returns timeout information for commands supported by the logical unit based on the time from the start of processing for the command to its reported completion.

Values returned in the command timeouts descriptor do not include times that are outside the control of the device.

The Command Timeout Descriptor is included only if the RCTD bit in the Report Supported Operation Codes CDB = 1.

TABLE 3-135 Command Timeouts Descriptor Format

Byte	Bit 7	6	5	4	3	2	1	0
0 thru 1	(MSB) Description Length (000Ah) (LSB)							
2	Reserved							
3	Command Specific							
4 thru 7	(MSB) Nominal Command Processing Timeout (LSB)							
8 thru 11	(MSB) Recommended Command Timeout (LSB)							

Parameter	Value
Description Length	Indicates the number of bytes that follow in the command timeouts descriptor.
Command Specific	Contains timeout information specific to one or more commands. If no command specific timeout information is defined this field is reserved.
Nominal Command Processing Timeout	0 = No timeout is indicated A non-zero value = Indicates the minimum amount of time in seconds the application client should wait prior to querying for the progress of the command Note: The value contained in this field may include time required for typical device error recovery procedures expected to occur on a regular basis.
Recommended Command Timeout	0 = No time is indicated A non-zero value = Specifies the recommended time in seconds the application client should wait before timing out the command

Report Supported Task Management Functions Command

The Report Supported Task Management Functions command returns information about the task management functions supported by the tape drive.

TABLE 3-136 Report Supported Task Management Functions Command

Byte	Bit 7	6	5	4	3	2	1	0
0	Operation Code (A3h)							
1	Reserved			Service Action (0Dh)				
2 thru 5	(MSB) Reserved (LSB)							
6 thru 9	(MSB) Allocation Length (LSB)							
10	Reserved							
11	Control Byte							

Parameter	Value
Allocation length	Maximum length of data to return (4 or larger).

Supported Task Management Functions Data Format

TABLE 3-137 Report Supported Task Management Functions Data Format

Byte	Bit 7	6	5	4	3	2	1	0
0	ATS	ATSS	CACAS	CTSS	LURS	QTS	TRS	WAKEUP
1	Reserved					QAES	QTSS	ITNRS
2 thru 3	(MSB) Reserved (LSB)							

Parameter	Value
ATS	1 = Abort task supported
ATSS	1 = Abort task set supported
CACAS	0 = Clear ACA not supported
CTSS	1 = Clear task set supported
LURS	1 = Logical unit reset supported
QTS	0 = Query task not supported
TRS	1 = Target reset supported
WAKEUP	0 = Wakeup not supported
QAES	0 = Query asynchronous event not supported
QTSS	0 = Query task set not supported
ITNRS	0 = I_T Nexus reset not supported

Report Target Port Groups Command

The Report Target Port Groups command sends target port group information to the host.

TABLE 3-138 Report Target Port Groups Command

Byte	Bit 7	6	5	4	3	2	1	0
0	Operation Code (A3h)							
1	Reserved			Service Action (0Ah)				
2 thru 5	(MSB) Reserved (LSB)							
6 thru 9	(MSB) Allocation Length (LSB)							
10	Reserved							
11	Control Byte							

Parameter	Value
Allocation length	Maximum length of data to return 4 or larger.

Report Target Port Group Parameter Data Format

The format for the parameter data returned by the Report Target Port Groups command is shown in the following table.

TABLE 3-139 Report Target Port Group Parameter Data Format

Byte	Bit 7	6	5	4	3	2	1	0
0 thru 3	(MSB)			Return Data Length (n-3)				(LSB)
				Target Port Group Descriptors				
4	(MSB)			Port Group Descriptor (First) (See TABLE 3-140 on page 187)				(LSB)
thru				. . .				
n	(MSB)			Port Group Descriptor (Last) (See TABLE 3-140 on page 187)				(LSB)

Parameter	Value
Return Data Length	Indicates the length in bytes of the list of target port groups.

Target Port Group Descriptor Format

There shall be one target port group descriptor for each target port group.

TABLE 3-140 Target Port Group Descriptor Format

<table>
<tr><th rowspan="2">Byte</th><th colspan="8">Bit</th></tr>
<tr><th>7</th><th>6</th><th>5</th><th>4</th><th>3</th><th>2</th><th>1</th><th>0</th></tr>
<tr><td>0</td><td>PREF</td><td colspan="3">Reserved</td><td colspan="4">Asymmetric Access State</td></tr>
<tr><td>1</td><td>T_SUP</td><td>O_SUP</td><td colspan="2">Reserved</td><td>U_SUP</td><td>S_SUP</td><td>AN_SUP</td><td>AO_SUP</td></tr>
<tr><td>2 thru 3</td><td colspan="8">(MSB) Target Port Group (LSB)</td></tr>
<tr><td>4</td><td colspan="8">Reserved</td></tr>
<tr><td>5</td><td colspan="8">Status Code</td></tr>
<tr><td>6</td><td colspan="8">Vendor Specific</td></tr>
<tr><td>7</td><td colspan="8">Target Port Count</td></tr>
<tr><td colspan="9">Target Port Descriptors</td></tr>
<tr><td>8 thru 11</td><td colspan="8">(MSB) Target Port Descriptor (First) (See TABLE 3-141 on page 188) (LSB)</td></tr>
<tr><td>n-3 thru n</td><td colspan="8">(MSB) Target Port Descriptor (Last) (See TABLE 3-141 on page 188) (LSB)</td></tr>
</table>

Parameter	Value
PREF	1 = Preferred target port
AAS	Asymmetric Access State 0 = Active / Optimized
T_SUP	0 = Not supported
O_SUP	0 = Not supported
U_SUP	0 = Not supported
AN_SUP	0 = Not supported
AO_SUP	1 = Active / Optimized is supported
Target Port Group	1 = Target port group identification
Status Code	0 = No status available
Vendor Specific	0 = Not supported
Target Port Count	2 = Number of target ports

Target Port Descriptor Format

TABLE 3-141 Target Port Descriptor Format

<table>
<tr><th rowspan="2">Byte</th><th colspan="8">Bit</th></tr>
<tr><th>7</th><th>6</th><th>5</th><th>4</th><th>3</th><th>2</th><th>1</th><th>0</th></tr>
<tr><td>0
thru
1</td><td colspan="8">Obsolete</td></tr>
<tr><td>2
thru
3</td><td colspan="8">(MSB)
Relative Target Port Identifier
(LSB)</td></tr>
</table>

Parameter	Value
Relative Target Port Identifier	Contains a relative port identifier of a target port in the target port group.

Request Sense Command

The Request Sense command transfers sense data to the initiator.

TABLE 3-142 Request Sense Command

Byte	Bit 7	6	5	4	3	2	1	0
0	Operation Code (03h)							
1 thru 3	(MSB) Reserved (LSB)							
4	Allocation Length							
5	Control Byte							

Allocation Length: Maximum length of sense data to return to the host. The device currently supports 26 bytes of sense data.

Notes:

- FCP requires that Check Conditions be reported in the Response of the failing command with the Sense Bytes, this is called Auto Sense. When these Sense Bytes have been presented they are cleared. Therefore, there is no need to issue a Request Sense command after a command has completed with Check Condition.
- The Request Sense command can only return Check Condition status to report errors with the Request Sense command CDB. The Sense Bytes describing the error will be in the Response as Auto Sense.
- If a Request Sense command is issued to a tape drive that does not exist, a Check Condition is reported in the response, Auto Sense is returned with a sense key of Illegal Request.

One of the following types of sense data may be returned for an unsolicited Request Sense command:

- Good – Sense key = 0, No Sense
- Unit Attention – Sense key = 6, Unit Attention
- Deferred Errors – Response Code = 71h, Deferred Error

Sense data is cleared after:

- Resets: Power-on, LIP (AL_PD, AL_PS), SCSI Target, and SCSI Logical Unit
- Auto Sense presented to the Initiator in the command response
- A Request Sense command from the Initiator

Sense Data:

TABLE 3-143 Sense Data Format

Byte	Bit 7	6	5	4	3	2	1	0
0	Valid	Response Code (70h or 71h)						
1	Reserved							
2	Filemark	EOM	ILI	RSVD	Sense Key			
3 thru 6	(MSB) Information (LSB)							
7	Additional Sense Length (n-7)							
8 thru 11	(MSB) Command Specific Information (LSB)							
12	Additional Sense Code							
13	Additional Sense							
14	Field Replaceable Unit Code							
15	SKSV	(MSB)						
16	Sense Key Specific							
17								(LSB)
18 thru 23	(MSB) Fault Symptom Codes 1-3 (LSB)							
24	Tape Type				Davail	MIRBad	Volsafe	TapeEOL
25	Reserved						LibAtt	RSVD

Parameter	Value
Valid	0 = Information field does not contain valid data 1 = Information field contains valid data
Response Code	70h = Current error, sense data is for the command that received the check condition. 71h = Deferred error, sense data is for a previously issued command. The current command that received check condition was not executed.
Filemark	0 = Normal 1 = A `Read` or `Space` command encountered a filemark

Parameter	Value
EOM: End of Media	0 = Normal 1 = A Forward command encountered End of Media, or a Reverse Space command encountered BOT.
ILI: Illegal Length Indication	0 = Normal 1 = Requested record size did not match actual record size
Sense Key	Indicates general type of error or other condition.
Information	Contains residual or other information when the Valid bit is 1.
Additional Sense Length	Indicates the number of sense bytes that follow.
Command-specific Information	0 = Not supported
ASC: Additional Sense Code	Provides more detail about the error or other condition. Used with the Sense Key and ASCQ fields. See TABLE 3-147 on page 194..
ASCQ: Additional Sense Code Qualifier	Provides more detail about the error when used with ASC and Sense Key. See TABLE 3-147 on page 194.
Field Replaceable Unit Code	0 = Not supported

TABLE 3-144 Field Pointer Sense Key Illegal Request Specific Data

Byte	Bit							
	7	6	5	4	3	2	1	0
0	SKSV	C/D	Reserved		BPV	Bit Pointer		
1 thru 2	(MSB) Field Pointer (LSB)							

Parameter	Value
SKSV: Sense Key Specific Valid	Sense Key Specific fields Valid 0 = C/D and Field Pointer fields do not contain valid information. 1 = C/D and Field Pointer fields are valid. Only set when Sense Key is 5.
C/D: Command or Data field	Command or Data field. 0 = Illegal field in parameter data. 1 = Illegal field in Command Descriptor Block.
BPV: Bit Pointer Valid	0 = Not supported
Bit Pointer	0 = Not supported
Field Pointer	Indicates which field in parameter data or CDB is invalid. In the case of a multiple byte field, will point to the first byte of field in error.

TABLE 3-145 Progress Indication Sense Key Not Ready or No Sense Specific Data

Byte	Bit 7	6	5	4	3	2	1	0
0	SKSV	Reserved						
1 thru 2	(MSB) Progress Indication (LSB)							

Parameter	Value
SKSV: Sense Key Specific Fields Valid	0 = Progress indication not valid 1 = Progress indication valid. Only set when sense key is 0.
Progress Indication	Percent complete 0000h to FFFFh
FSC-1	Fault Symptom Code for the first error encountered while attempting the requested operation. The FSC codes are specific to the T10000 tape drives.
FSC-2	Fault Symptom Code for second error encountered.
FSC-3	Fault Symptom Code for last error encountered.
TapeType	Identifies type of tape currently loaded in drive. 1000b = Cleaning tape 0100b = Dump tape 0010b = Code load tape 0001b = Data tape 0000b = Unknown type
DAvail	Diagnostic information is Available
MIRBad	Metadata on the currently loaded tape is defective
Volsafe	Current tape is append only
TapeEOL	Tape currently loaded is at End Of Life (EOL)
LibAtt	Drive is Attached to a library

Sense Keys

TABLE 3-146 lists the Sense Keys that provides basic information about an error. The Sense Key, with the ASC and ASCQ, provides a description about an error.

TABLE 3-146 Sense Key Code Descriptions

Code	Description
0	**No Sense** Indicates there is no specific sense key information to be reported. A sense key of 0 indicates a successful command or a command that received a Check Condition status because of a filemark, end-of-medium, or illegal length indication. A sense key of 0 also indicates the tape drive needs cleaning.
2	**Not Ready** Indicates the addressed logical unit is not ready for tape motion commands (tape is not loaded, device is not ready).
3	**Medium Error** Indicates an unrecovered error condition that was probably caused by a defect in the tape or an error in the recorded data. This sense key may also be returned if the device cannot distinguish between a defect in the tape and/or a hardware failure, Sense Key 4.
4	**Hardware Error** Indicates the device detected an unrecoverable hardware failure while performing the command or during a self-test.
5	**Illegal Request** Indicates an illegal parameter in the Command Descriptor Block or parameter data.
6	**Unit Attention** Indicates a tape may have been changed, the device was reset, or parameters were changed by another host.
7	**Data Protect** Indicates a command that reads or writes to the tape was attempted on a block that is protected from this operation. The read or write operation was not performed.
8	**Blank Check** Indicates the device encountered blank tape.
B	**Aborted Command** Indicates the device aborted the command. The initiator may be able to recover by trying the command again.
D	**Volume Overflow** Indicates a buffered device has reached the end-of-tape and data remains in the buffer.
E	Miscompare Indicates that the source data did not match the read data from the medium (Logical Block Protection Methods did not agree).

Additional Sense Codes and Qualifiers

TABLE 3-147 lists the Additional Sense Code and Qualifiers found in Bytes 12 and 13 of the sense data. These codes provide additional information about an error.

TABLE 3-147 Sense Key with ASC and ASCQ

	Byte		
Key	**12**	**13**	**Description**
0	00	00	No additional sense information
	00	01	Filemark detected
	00	02	End of partition/medium detected
	00	04	Beginning of partition/medium detected (read or space reverse into BOT)
	00	17	Cleaning requested
	00	18	Erase operation in progress
	00	1C	Verify operation in progress
	5B	02	Log counter at maximum
2	04	01	Logical unit is in the process of becoming ready (load immediate cmd.)
	04	03	Logical unit not ready, manual intervention required (drive is offline)
	30	03	Cleaning cartridge installed (cleaning)
	3A	00	Medium not present
	53	00	Media load or eject failed
3	00	02	End of partition/medium detected
	0C	00	Write error (write data check)
	11	01	Read retries exhausted (read data check)
	11	02	Error too long to correct
	11	0E	Decompression failure (can't decompress using this algorithm)
	14	04	Block sequence error (block ID in record header was out of sequence)
	15	00	Random positioning error
	26	05	Data decryption error
	30	00	Incompatible medium installed (tape too long)
	30	01	Cannot read medium, unknown format (density ID read failed)
	30	02	Cannot read medium, incompatible format (illegal data format)
	31	00	Medium format corrupted (cannot write density ID)
	33	00	Tape length error (short tape error)
	3B	00	Sequential positioning error
	3B	01	Tape position error at beginning-of-tape
	3B	08	Reposition error (CU ERP failed and we are lost)
	51	00	Erase failure (long erase check)

TABLE 3-147 Sense Key with ASC and ASCQ (Continued)

	Byte		
Key	**12**	**13**	**Description**
4	03	00	Peripheral device write fault (used when a prior check message locks out a load display command)
	04	80	Drive reported failure
	08	00	Logical unit or communication failure
	08	01	Logical unit timeout
	10	01	Logical block guard check failed
	10	02	Logical block application tag check failed
	10	03	Logical block reference tag check failed
	15	01	Mechanical positioning error (tape lost tension)
	24	8B	Firmware corrupted
	26	81	No encryption keys loaded
	40	80	Diagnostic failure on component (Self-test failed)
	44	00	Internal target failure (internally detected hardware errors)
	44	B0	Multiple bus drivers detected during buffer DMA
	44	B1	RAM port parity error detected during buffer DMA
	44	B3	CRC/LRC generation failed during buffer DMA
	44	B4	CRC/LRC check failed during buffer DMA
	44	B5	DMA zero byte count flag not set after completion
	44	B6	Tape drive detected a hardware error in the data path
	44	B7	Hardware error in the servo or a bad sensor
	44	B8	Permanent hardware malfunction in the tape drive
	44	C0	Internal DMA transmit failure
	44	C1	Internal DMA receive failure
	45	00	Select or reselect failure
	4B	80	Under run during data phase
	4B	81	Over run during data phase
	4B	82	DMA error during data phase
	51	00	Erase fault
	52	00	Cartridge fault (a load/eject command failure reported by CSL)
	53	01	Unload tape failure (tape unload check)

TABLE 3-147 Sense Key with ASC and ASCQ (Continued)

	Byte		
Key	**12**	**13**	**Description**
5	1A	00	Parameter list length error (mode select or other parameter data was truncated)
	20	00	Invalid command operation code (first byte of CDB is not a supported cmd)
	21	00	Logical block address out of range
	24	00	Invalid field in CDB (unsupported or illegal bits are set, field pointer indicates where)
	24	80	Write command has 1 through 4 as an invalid transfer count for the Data Protection mode selected.
	24	81	Write command has non modulo 4 or less than 8 as an invalid transfer count for the Data Protection mode selected.
	24	82	Media loaded in drive (attempted Write Buffer or Read Buffer command with tape in the drive)
	24	83	DIV T10 PI transfer count is not a modulo of the T10 PI Exponent size.
	24	8E	Invalid firmware image
	25	00	Logical unit not supported (only LUN 0 supported)
	26	00	Invalid field in parameter list (unsupported or reserved bits are set, field pointer indicates where)
	26	04	Invalid release of Persistent Reservation
	26	11	Incomplete key-associated data set
	2C	00	Command sequence error
	30	02	Incompatible format
	30	05	Cannot write medium - incompatible format
	30	06	Cannot format medium - incompatible medium
	39	00	Saving parameters not supported
	3B	0C	Partition past beginning of partition
	3F	0F	Echo buffer overwritten
	4B	90	FCP_DL field not sufficient to complete the transfer
	80	00	CSL not present (a load command was issued, but CSL not installed)
	80	01	Invalid CSL position requested
	80	02	CSL not ready (no cartridge loaded)
	80	03	Load command received and the load is in progress

TABLE 3-147 Sense Key with ASC and ASCQ (Continued)

	Byte		
Key	**12**	**13**	**Description**
6	28	00	Not ready to ready transition (medium may have changed)
	29	00	Power on or reset occurred
	2A	00	Parameters changed
	2A	01	Mode parameters changed by another host
	2A	02	Log parameters changed by another host
	2A	03	Reservation pre-empted by another host
	2A	04	Reservations released by another host
	2A	05	Reservation pre-empted by another host
	3F	01	Microcode has been changed
7	26	10	Data decryption key fail limit reached
	27	00	Write protected (and a write-type of command was attempted)
	27	80	Unable to overwrite data
	2A	13	Data encryption key instance counter has changed
	30	05	Cannot write medium - incompatible format
	74	01	Unable to decrypt data
	74	02	Unencrypted data encountered while decrypting
	74	03	Incorrect data encryption key
	74	04	Cryptographic Integrity Validation Failed
8	00	05	End-of-data detected
	14	00	Recorded entity not found (no EOD, but tape appears to be blank).
B	00	06	I/O process terminated due to errors
	11	00	Unrecovered read error during FCP-2 recovery
	47	00	SCSI parity error (retries not successful)
	48	00	Initiator detected error message received
	49	00	Invalid message error
	4A	00	Command phase error
	4B	00	Data phase error
	4B	83	Command timeout
	4B	84	Re-selection timeout
	4E	00	Overlapped commands attempted
D	00	02	End-of-partition/medium detected (unable to write all data to tape)
	00	04	Beginning-of-partition/medium detected
E	10	05	Logical Block Protection Method error

Request Sense Command (59 Byte)

The progress of a StorageTek T10000 Media Validation operation may be monitored using the Request Sense command. Verify Percent Complete is reported in the Sense Key Specific (Byte 15 (bits 0 thru 6) and Bytes 16 and 17) only when a StorageTek T10000 Media Validation operation is in progress (indicated by the Additional Sense Code and Additional Sense Code Qualifier bytes being set to 00h and 1Ch, respectively).

TABLE 3-148 Data Returned for Request Sense Command

Byte	Bit 7	6	5	4	3	2	1	0
0 thru 1	Valid	(MSB) Response Code (70h or 71h) (LSB)						
2	Filemark	EOM	ILI	RSVD	Sense Key			
3 thru 6	(MSB) Information (LSB)							
7	Additional Sense Length(n-7)							
8 thru 11	(MSB) Command Specific Information (LSB)							
12	Additional Sense Code							
13	Additional Sense Code Qualifier							
14	Field Replaceable Unit Code							
15	SKSV	Sense Key Specific						
16 thru 17	(MSB) Sense Key Specific (LSB)							
18 thru 23	(MSB) Fault Symptom Codes 1-3 (LSB)							
24	Tape Type				DAvail	MIRBAD	Volsafe	TapeEOL
25	Reserved						LibAtt	RSVD
26 thru 29	(MSB) Reserved (LSB)							
30 thru 37	(MSB) Last HLU ID verified (LSB)							
38 thru 41	(MSB) Last partition verified (LSB)							

TABLE 3-148 Data Returned for Request Sense Command (Continued)

Byte	Bit 7	6	5	4	3	2	1	0
42	Perm							
43 thru 46	(MSB) Elapsed time (LSB)							
47 thru 54	(MSB) Start HLU ID (LSB)							
55 thru 58	(MSB) Start partition (LSB)							

Reserve Command

The Reserve Unit command reserves a device for the exclusive use of one initiator. The device returns Reservation Conflict status if any other initiator sends a command to the device except for Sense, Inquiry, or Release Unit Commands. Reservations are canceled with a reset or Release Unit.

TABLE 3-149 Reserve—6 Byte Command

Byte	Bit 7	6	5	4	3	2	1	0
0	Operation Code (16h)							
1	Reserved			Obsolete				
2	Reservation Identification							
3 thru 4	(MSB) Parameter List Length (LSB)							
5	Control Byte							

TABLE 3-150 Reserve—10 Byte Command

Byte	Bit 7	6	5	4	3	2	1	0
0	Operation Code (56h)							
1	Reserved			3rd Pty	Reserved		LongID	Obsolete
2	Reservation Identification							
3	Third Party Device ID							
4 thru 6	(MSB) Reserved (LSB)							
7 thru 8	(MSB) Parameter List Length (LSB)							
9	Control Byte							

Parameter	Value
Parameter List Length	0 = Not supported
3rd Pty	0 = Not supported
LongID	0 = Not supported
Reservation ID	0 = Not supported
Third Party Device ID	0 = Not supported

Rewind Command

The Rewind command causes the device to rewind the media to the beginning-of-tape (BOT). The device writes any buffered write data on tape before the rewind starts.

Caution – If the drive is in Buffered Mode and a previous command terminated with Check Condition status (such as, buffered data unwritten to tape and the condition was not cleared or otherwise recovered), the drive will discard any unwritten buffered data and filemarks before this operation starts.

TABLE 3-151 Rewind Command

Byte	Bit 7	6	5	4	3	2	1	0
0	Operation Code (01h)							
1	Reserved							Immed
2 thru 4	(MSB) Reserved (LSB)							
5	Control Byte							

Parameter	Value
Immed	Immediate bit: 0 = Return status when rewind completes 1 = Return status after all buffered data is written on tape and rewind starts.

Note – Issuing a Test Unit Ready command after a Rewind command with the Immed bit set returns Busy status until the rewind completes.

Security Protocol In Command

The Security Protocol In (SPIN) command returns information about security and encryption

TABLE 3-152 Security Protocol In Command (SPIN)

Byte	Bit 7	6	5	4	3	2	1	0
0	Operation Code (A2h)							
1	Security Protocol							
2 thru 3	(MSB) Security Protocol Specific (LSB)							
4	INC512 (0)	Reserved						
5	Reserved							
6 thru 9	(MSB) Allocation Length (LSB)							
10	Reserved							
11	Control Byte							

Parameter	Value
Security Protocol	The Security Protocol field specifies which security protocol is being requested. • 00h = Security Protocol Information • 20h = Tape Data Encryption

Parameter	Value
Security Protocol Specific	The Security Protocol Specific specifies the type of page being requested. When Security Protocol is 00h; • 0000h = Supported Security Protocol List • 0001h = Certificate Data When Security Protocol is 20h; • 0000h = Tape Data Encryption In Support page • 0001h = Tape Data Encryption Out Support page • 0010h = Data Encryption Capabilities page • 0011h = Supported Key Formats page • 0012h = Data Encryption Management Capabilities page • 0020h = Data Encryption Status page • 0021h = Next Block Encryption Status page
INC512	Allocation length increment 0 = Normal allocation length

Security Protocol Information Pages

Supported Security Protocol List

A request of Security Protocol of 00h and a Security Protocol Specific 0000h will return a list of supported security protocols.

TABLE 3-153 Security Protocol List

Byte	Bit 7	6	5	4	3	2	1	0
0 thru 5	(MSB) Reserved (LSB)							
6 thru 7	(MSB) Length of remaining data in bytes (0002h) (LSB)							
8	Security Protocol Information (00h)							
9	Tape Data Encryption (20h)							

Certificate Data

A request of Security Protocol of 00h and a Security Protocol Specific 0001h will return the certificate data.

TABLE 3-154 Certificate Data

Byte	Bit 7	6	5	4	3	2	1	0
0 thru 1	(MSB) Reserved (LSB)							
2 thru 3	(MSB) Length of Certificate Data (0000h) (LSB)							

Note – A length of 0 (zero) indicates no certificate available.

Tape Data Encryption Pages

Tape Data Encryption In Supported Page

A request of Security Protocol of 20h and a Security Protocol Specific 0000h will return a list of supported values for the Security Protocol Specific field supported by the SPIN command.

TABLE 3-155 Tape Data Encryption In Supported Page

Byte	Bit 7	6	5	4	3	2	1	0
0 thru 1	(MSB) Page Code (0000h) (LSB)							
2 thru 3	(MSB) Page Length in bytes (000Eh) (LSB)							
4 thru 5	(MSB) Tape Data Encryption In Support (0000h) (LSB)							
6 thru 7	(MSB) Tape Data Encryption Out Support (0001h) (LSB)							
8 thru 9	(MSB) Data Encryption Capabilities (0010h) (LSB)							
10 thru 11	(MSB) Supported Key Formats (0011h) (LSB)							
12 thru 13	(MSB) Data Encryption Management Capabilities (0012h) (LSB)							
14 thru 15	(MSB) Data Encryption Status (0020h) (LSB)							
16 thru 17	(MSB) Next Block Encryption Status (0021h) (LSB)							

Tape Data Encryption Out Supported Page

A request of Security Protocol of 20h and a Security Protocol Specific 0001h will return a list of supported values for the Security Protocol Specific field supported by the Security Protocol Out (SPOUT) command.

TABLE 3-156 Tape Data Encryption Out Supported Page

Byte	Bit 7	6	5	4	3	2	1	0
0 thru 1	(MSB) Page Code (0001h) (LSB)							
2 thru 3	(MSB) Page Length in bytes (0002h) (LSB)							
4 thru 5	(MSB) Set Data Encryption (0010h) (LSB)							

Data Encryption Capabilities Page

A request of Security Protocol of 20h and a Security Protocol Specific 0010h will return information regarding data encryption algorithms supported.

TABLE 3-157 Tape Data Encryption Capabilities Page

Byte	Bit 7	6	5	4	3	2	1	0
0 thru 1	(MSB) Page Code (0010h) (LSB)							
2 thru 3	(MSB) Page Length in bytes (0028h) (LSB)							
4	Reserved				EXTDECC (00b)		CFG_P (01b)	
5 thru 19	(MSB) Reserved (LSB)							
20 thru 43	(MSB) Data Encryption Algorithm Descriptor (LSB)							

Parameter	Value
EXTDECC: External data encryption control capable	External data encryption control capable 00b = The external data encryption control capability is not supported
CFG_P: Configuration prevented	Configuration prevented 01b = Drive is configured to allow changes of data encryption parameters

Data Encryption Algorithm Descriptor

TABLE 3-158 Data Encryption Algorithm Descriptor

<table>
<tr><th rowspan="2">Byte</th><th colspan="8">Bit</th></tr>
<tr><th>7</th><th>6</th><th>5</th><th>4</th><th>3</th><th>2</th><th>1</th><th>0</th></tr>
<tr><td>0</td><td colspan="8">Algorithm Index (01h)</td></tr>
<tr><td>1</td><td colspan="8">Reserved</td></tr>
<tr><td>2
thru
3</td><td colspan="8">(MSB)
Descriptor Length (0014h)
(LSB)</td></tr>
<tr><td>4</td><td>AVFMV</td><td>SDK_C
(0)</td><td>MAC_C
(0)</td><td>DELB_C
(1)</td><td colspan="2">Decrypt_C
(10b)</td><td colspan="2">Encrypt_C
(10b)</td></tr>
<tr><td>5</td><td colspan="2">AVFCLP
(00b)</td><td colspan="2">NONCE_C
(01b)</td><td>Rsvd</td><td>VCELB_C
(0)</td><td>UKADF
(0)</td><td>AKADF
(0)</td></tr>
<tr><td>6
thru
7</td><td colspan="8">(MSB)
Maximum Unauthenticated Key-Associated Data Bytes (001Eh)
(LSB)</td></tr>
<tr><td>8
thru
9</td><td colspan="8">(MSB)
Maximum Authenticated Key-Associated Data Bytes (0000h)
(LSB)</td></tr>
<tr><td>10
thru
11</td><td colspan="8">(MSB)
Key Size (0020h)
(LSB)</td></tr>
<tr><td>12</td><td colspan="2">DKAD_C
(01b)</td><td colspan="2">EEMC_C
(00b)</td><td colspan="3">RDMC_C
(001b)</td><td>EAREM
(1)</td></tr>
<tr><td>13</td><td colspan="8">Reserved</td></tr>
<tr><td>14
thru
15</td><td colspan="8">(MSB)
MSDK_Count
(LSB)</td></tr>
<tr><td>16
thru
19</td><td colspan="8">(MSB)
Reserved
(LSB)</td></tr>
<tr><td>20
thru
23</td><td colspan="8">(MSB)
Security Algorithm Code (80010010h)
(LSB)</td></tr>
</table>

Parameter	Value
AVFMV	Algorithm valid for mounted volume 0 = Not valid or no volume mounted 1 = Valid
SDK_C	Supplemental decryption key capable 0 = Not supported
MAC_C	Message authentication code capable 0 = Not supported
DELB_C	Distinguish encrypted logical block capable 1 = Drive can distinguish encrypted data from unencrypted data when reading from the media
Decrypt_C	Decryption capable 10b = Drive can decrypt using this algorithm in hardware
Encrypt_C	Encryption capable 10b = Drive can encrypt using this algorithm in hardware
AVFCLP	Algorithm valid for current logical position 00b = Algorithm valid regardless of logical position or no volume is loaded
NONCE_C	Nonce capable. 01b = Drive generates nonce values
VCELB_C	Volume contains encrypted logical blocks capable 0 = Drive can determine that volume contains encrypted data when the volume is mounted
UKADF	U-KAD fixed (Unauthenticated Key-Associated Data) 0 = Not fixed length
AKADF	A-KAD fixed (Authenticated Key-Associated Data) 0 = Not fixed length
Maximum Unauthenticated Key-Associated data bytes	001Eh
Maximum Authenticated Key-Associated data bytes	0000h = Not supported
Key size	0020h = Device uses 256 bit keys

Parameter	Value
DKAD_C	Decryption KAD capable when Decryption Mode is Decrypt or Mixed 00b = Not specified (Not supported) 01b = Drive requires a U-KAD provided by the Host for decrypting operations. If not provided with SPOUT command Set Data Encryption page then terminate the command with Check Condition with sense key set to Illegal Request and the ASC set to Incomplete Key-Associated Date Set. 10b = Not required (Not supported) 11b = Optional (Not supported)
EEMC_C	External encryption mode capabilities 00b = Not supported
RDMC_C	Raw decryption mode capable 001b = Raw decryption mode not supported
EAREM	Encryption mode recorded 1 = Encryption mode is recorded with each logical block
MSDK_Count	Maximum supplemental decryption key count supported 00000000h = Currently not supported
Security Algorithm Code	80010010h = ENCR_AES_CCM16 (RFC 4309)

Note – Advanced Encryption Standard—AES—is a block cipher encryption algorithm that uses Counter with CBC-MAC (Cipher Block Chaining–Message Authentication Code), or CCM, as a mode of encryption that provides both a strong form of privacy (security) and efficient authentication.

Supported Key Formats Page

A request of Security Protocol of 20h and a Security Protocol Specific 0011h will return a list of all supported key formats.

TABLE 3-159 Supported Keys Formats Page

Byte	Bit 7	6	5	4	3	2	1	0
0 thru 1	(MSB)			Page Code (0011h)				(LSB)
2 thru 3	(MSB)			Page Length in bytes (0001h)				(LSB)
4				Supported Key Formats (00h)				

Parameter	Value
Supported Key Formats	00h = Plain text Keys

Data Encryption Management Capabilities Page

A request of Security Protocol of 20h and a Security Protocol Specific 0012h will return information about encryption management features supported.

TABLE 3-160 Data Encryption Capabilities Management Page

Byte	Bit 7	6	5	4	3	2	1	0
0 thru 1	(MSB) Page Code (0012h) (LSB)							
2 thru 3	(MSB) Page Length in bytes (000Ch) (LSB)							
4	Reserved							LOCK_C (1)
5	Reserved					CKOD_C (1)	CKORP_C (1)	CKORL_C (1)
6	Reserved							
7	Reserved					AITN_C (1)	LOCAL_C (1)	PUBLIC_C (1)
8 thru 15	(MSB) Reserved (LSB)							

Parameter	Value
LOCK_C	LOCK bit supported in the Set Data Encryption page 1 = Supported
CKOD_C	Clear key on demount bit supported in the Set Data Encryption page 1 = Supported
CKORP_C	Clear key on reservation preempt bit supported in the Set Data Encryption page 1 = Supported
CKORL_C	Clear key on reservation loss bit supported in the Set Data Encryption page 1 = Supported
AITN_C	All I_T Nexus bit supported in the Set Data Encryption page 1 = Supported

Parameter	Value
LOCAL_C	LOCAL bit supported in the Set Data Encryption page 1 = Supported
PUBLIC_C	PUBLIC bit supported in the Set Data Encryption page 1 = Supported

Data Encryption Status Page

A request of Security Protocol of 20h and a Security Protocol Specific 0020h will return the current data encryption status.

TABLE 3-161 Data Encryption Status Page

<table>
<tr><th rowspan="2">Byte</th><th colspan="8">Bit</th></tr>
<tr><th>7</th><th>6</th><th>5</th><th>4</th><th>3</th><th>2</th><th>1</th><th>0</th></tr>
<tr><td>0 thru 1</td><td colspan="8">(MSB) Page Code (0020h) (LSB)</td></tr>
<tr><td>2 thru 3</td><td colspan="8">(MSB) Page Length in bytes (n -3) (LSB)</td></tr>
<tr><td>4</td><td colspan="3">I_T Nexus Scope</td><td colspan="2">Reserved</td><td colspan="3">Logical Block Encryption Scope</td></tr>
<tr><td>5</td><td colspan="8">Encryption Mode</td></tr>
<tr><td>6</td><td colspan="8">Decryption Mode</td></tr>
<tr><td>7</td><td colspan="8">Algorithm Index</td></tr>
<tr><td>8 thru 11</td><td colspan="8">(MSB) Key Instance Counter (LSB)</td></tr>
<tr><td>12</td><td>Rsvd</td><td colspan="3">Parameters Control (010b)</td><td>VCELB (0)</td><td colspan="2">CEEMS (01b)</td><td>RDMD (0)</td></tr>
<tr><td>13</td><td colspan="8">Reserved</td></tr>
<tr><td>14 thru 15</td><td colspan="8">(MSB) ASDK_Count (LSB)</td></tr>
<tr><td>16 thru 23</td><td colspan="8">(MSB) Reserved (LSB)</td></tr>
<tr><td>24 thru n</td><td colspan="8">(MSB) Key Association Descriptor List (LSB)</td></tr>
</table>

Parameter	Value
I_T Nexus Scope	I_T nexus of the saved data encryption parameters 000b = Public 001b = Local 010b = All I_T Nexus
Logical Block Encryption Scope	Logical block encryption scope of the saved data encryption parameters 000b = Public 001b = Local 010b = All I_T Nexus
Encryption Mode	Encryption mode of the saved data encryption parameters 00h = Data encryption is disabled 02h = Write data will be encrypted
Decryption Mode	Decryption mode of the saved data encryption parameters 00h = Data decryption is disabled 02h = Decrypt mode, encrypted data will be decrypted 03h = Mixed mode, encrypted data will be decrypted and non encrypted data read
Algorithm Index	Algorithm index of the saved data encryption parameters 00h = Not valid, such as encryption & decryption not enabled 01h = Algorithm to be used for encryption and decryption
Key Instance Counter	Key instance counter assigned to the key indicated in the key scope field
Parameters Control	Information on how the data encryption parameters are controlled 010b = Parameters are exclusively controlled by the device
VCELB	Volume contains encrypted logical blocks 0 = Capability is not supported
CEEMS	Check external encryption mode status 00b = Vendor Specific (Ignored) 01b = Encryption mode is not checked
RDMD	Raw decryption mode disabled 0 = Default mode
ASDK_Count	Available supplemental decryption key count 00000000h = Currently Not Supported
Key-Associated Data Descriptors List	The following key association descriptors are returned in the Key Descriptor Type order, TABLE 3-162 on page 213

Key-Associated Data Descriptors List

The following key association descriptors are returned in the Key Descriptor Type order.

TABLE 3-162 Key Association Descriptor Type

Byte	Bit 7	6	5	4	3	2	1	0
0	Key Descriptor Type							
1	Reserved					Authenticated		
2 thru 3	(MSB) Key Descriptor Length in bytes (n-3) (LSB)							
4 thru n	(MSB) Key Descriptor (LSB)							

Parameter	Value
Key Descriptor Type	00h = Unauthenticated key-associated data: U-KAD 01h = Authenticated key-associated data: A-KAD (not supported) 02h = Nonce value (not supported) 03h = Metadata key-associated data (not supported)
Authenticated	000b = Reserved
Key Descriptor Length	For U-KAD = Up to 001Eh bytes

Next Block Encryption Status Page

A request of Security Protocol of 20h and a Security Protocol Specific 0021h will return the next block encryption status.

TABLE 3-163 Next Block Encryption Status

Byte	Bit 7	6	5	4	3	2	1	0
0 thru 1	(MSB) Page Code (0021h) (LSB)							
2 thru 3	(MSB) Page Length in bytes (n-3) (LSB)							
4 thru 11	(MSB) Logical Object Number (LSB)							
12	Compression Status (0h)				Encryption Status			
13	Algorithm Index							
14	Reserved						EMES (0)	RDMDS (0)
15	Reserved							
16 thru n	(MSB) Key-Associated Data Descriptors List (LSB)							

Parameter	Value
Logical Object Number	Logical block address
Compression Status	0h = The drive is incapable of determining if the logical object referenced has been compressed
Encryption Status	• 1h = Drive is capable of determining if the logical block referenced has been encrypted, but is not able to at this time, for example: not read into the buffer, error, end of data • 2h = Drive has determined the logical block is not a logical block • 3h = Drive has determined the logical block is not encrypted • 5h = Drive has determined the logical block is encrypted • 6h = Drive has determined that the logical block is encrypted, but the drive is either not enabled to decrypt or does not have the correct key to decrypt the encrypted block
Algorithm Index	00h = Not valid, for example: encryption and decryption not enabled 01h = Default algorithm index
EMES	Encryption mode external status 0 = Not supported

Parameter	Value
RDMDS	Raw decryption mode disabled status 0 = Not supported
Key-Associated Data Descriptors List	The key-associated data descriptors are only returned on Encryption Status 6h. The following key association descriptors are returned in the Key Descriptor Type order:

Key-Associated Data Descriptors List

The key-associated data descriptors are only returned on Encryption Status 6h and in the following Key Descriptor Type order.

TABLE 3-164 Key-Associated Data Descriptors

	Bit							
Byte	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	Key Descriptor Type							
1	Reserved					Authenticated		
2 thru 3	(MSB) Key Descriptor Length in bytes (n-3) (LSB)							
4 thru n	(MSB) Key Descriptor (LSB)							

Parameter	Value
Key Descriptor Type	00h = Unauthenticated key-associated data: U-KAD
	01h = Authenticated key-associated data: A-KAD (not supported)
	02h = Nonce value (not supported)
	03h = Metadata key-associated data (not supported)
Authenticated	000b = Reserved
	001b = The value in the key descriptor field is not covered by authentication, for example: U-KAD
Key Descriptor Length	For U-KAD = Up to 001Eh bytes

SPIN Implementation Notes

The following table lists the possible key-associated data (KAD) parameters reported in the Next Block Encryption Status page.

TABLE 3-165 Key-Associated Data Reported Parameters (SPIN)

				Key-Associated Descriptors				
Record Information	**Decryption Mode**	**Read Data**	**Encryption Status**	**U-KAD 00h**	**A-KAD 01h**	**Nonce 02h**	**Metadata 03h**	**Notes**
Unknown	Any	?	1h	n/a	n/a	n/a	n/a	
Filemark	Any	n/a	2h	n/a	n/a	n/a	n/a	
EOD	Any	n/a	2h	n/a	n/a	n/a	n/a	
Error	Any	n/a	1h	n/a	n/a	n/a	n/a	
Unencrypted	Disable	Cleartext	3h	n/a	n/a	n/a	n/a	
Unencrypted	Raw							Not Supported
Unencrypted	Decrypt	Error	3h	n/a	n/a	n/a	n/a	Unreadable
Unencrypted	Mixed	Cleartext	3h	n/a	n/a	n/a	n/a	
Encrypted	Disable	Error	5 or 6	Y	N	N	N	Unreadable
Encrypted	Raw							Not Supported
Encrypted	Decrypt	Decrypted	5 or 6	Y	N	N	N	
Encrypted	Mixed	Decrypted	5 or 6	Y	N	N	N	

- If the SECURITY PROTOCOL or the SECURITY PROTOCOL SPECIFIC field is set to a reserved or unsupported value, the device server shall terminate the command with CHECK CONDITION status, with the sense key set to ILLEGAL REQUEST, and the additional sense code set to INVALID FIELD IN CDB.
- If the SPIN command is sent to an older drive firmware that does not support the SPIN/SPOUT commands, the drive shall terminate the command with CHECK CONDITION status, with the sense key set to ILLEGAL REQUEST, and the additional sense code set to INVALID COMMAND OPERATION CODE.
- If the SPIN command is sent to a drive that has not been configured for DPKM support, the drive shall terminate the command with CHECK CONDITION status, with the sense key set to ILLEGAL REQUEST, and the additional sense code set to INVALID FIELD IN CDB such as the Security Protocol field).
- If the Spin command requesting Next Block Encryption Status is sent to a drive that does not have a volume mounted, the drive shall terminate the command with CHECK CONDITION status, with the sense key set to NOT READY, and the additional sense code set to MEDIUM NOT PRESENT.

Security Protocol Out Command

The Security Protocol Out (SPOUT) command specifies the Tape Data Encryption security protocol to be used when encrypting and decrypting.

TABLE 3-166 Security Protocol Out Command (SPOUT)

Byte	Bit 7	6	5	4	3	2	1	0
0	Operation Code (B5h)							
1	Security Protocol (20h)							
2 thru 3	(MSB) Security Protocol Specific (0010h) (LSB)							
4	INC_512 (0)	Reserved						
5	Reserved							
6 thru 9	(MSB) Transfer Length (LSB)							
10	Reserved							
11	Control Byte							

Parameter	Value
Security Protocol	The Security Protocol field specifies which security protocol is being requested. 20h = Tape Data Encryption
Security Protocol Specific	The Security Protocol Specific specifies the type of page that is being requested. 0010h = Set Data Encryption page
INC512	Allocation length increment 0 = Normal allocation length

Set Data Encryption Page

A request of Security Protocol of 20h and a Security Protocol Specific 0010h will select the data encryption capabilities of the drive.

TABLE 3-167 Set Data Encryption Page

Byte	Bit 7	6	5	4	3	2	1	0
0 thru 1	(MSB) Page Code (0010h) (LSB)							
2 thru 3	(MSB) Page Length in bytes (m-3) (LSB)							
4	Scope			Reserved				Lock
5	CEEM (01b)		RDMC (00b)		SDK (0)	CKOD	CKORP	CKORL
6	Encryption Mode							
7	Decryption Mode							
8	Algorithm Index (01h)							
9	Logical Block Encryption Key Format (00h)							
10 thru 17	(MSB) Reserved (LSB)							
18 thru 19	(MSB) Logical Block Encryption Key Length (0020h) (LSB)							
20 thru 51	(MSB) Logical Block Encryption Key (LSB)							
52 thru m	(MSB) Key-Associated Data Descriptors List (LSB)							

Parameter	Value
Scope	Scope of the data encryption parameters 000b = Public 001b = Local 010b = All I_T Nexus
Lock	0 = Not locked 1 = Locked
CEEM	Check external encryption mode 00b = Vendor Specific (Ignored) 01b = Encryption mode is not checked
RDMC	Raw decryption mode disabled 00b = Default mode
SDK	Supplemental decryption key 0 = Not supported
CKOD	Clear key on volume demount 0 = No 1 = Yes
CKORP	Clear key on reservation preempt 0 = No 1 = Yes
CKORL	Clear key on reservation loss 0 = No 1 = Yes
Encryption Mode	Encryption mode 00h = Data encryption is disabled 02h = Write data will be encrypted
Decryption Mode	Decryption mode 00h = Data decryption is disabled 02h = Decrypt mode, encrypted data will be decrypted 03h = Mixed mode, encrypted data will be decrypted and non encrypted data will be read
Algorithm Index	Algorithm index of the saved data encryption parameters 01h = Algorithm to be used for encryption and decryption
Logical Block Encryption Key Format	Key format of the value in the key field 00h = Plain-text key
Logical Block Encryption Key Length	0020h = Length in bytes of the key field, drive uses 256 bit keys
Logical Block Encryption Key	Host supplied plain-text key

Key-Associated Data Descriptors List

The following key association descriptors must be provided in Key Descriptor Type order.

Note –

- If the U-KAD descriptor is not present when Encryption Mode is enabled a 30 byte Key Descriptor of all zeroes is used.
- In the future if this drive supports Supplemental Decryption Keys then the Host will be required to supply the U-KAD when Encryption Mode is enabled.

TABLE 3-168 Key Association Descriptor Format

Byte	Bit 7	6	5	4	3	2	1	0
0	Key Descriptor Type							
1	Reserved					Authenticated		
2 thru 3	(MSB) Key Descriptor Length in bytes (n-3) (LSB)							
4 thru n	(MSB) Key Descriptor (LSB)							

Parameter	Value
Key Descriptor Type	00h = Unauthenticated key-associated data: U-KAD 01h = Authenticated key-associated data: A-KAD (not supported) 02h = Nonce value (not supported) 03h = Metadata key-associated data (not supported)
Authenticated	000b = Reserved
Key Descriptor Length	For U-KAD = Up to 001Eh bytes

SPOUT Implementation Notes

The following table lists the possible Key-Associated Data (KAD) parameters supported in the Set Data Encryption page.

TABLE 3-169 Key-Associated Data Reported Parameters (SPOUT)

				Key-Associated Descriptors				
Record Information	**Decryption Mode**	**Read Data**	**Encryption Status**	**U-KAD 00h**	**A-KAD 01h**	**Nonce 02h**	**Metadata 03h**	**Notes**
0h Disable	0h Disable	C/C	P	P	P	P	P	
0h Disable	1h Raw							Not Supported
0h Disable	2h Decrypt	D/C	M	M[1]	P	P	P	
0h Disable	3h Mixed	D/C	M	M[1]	P	P	P	
1h External	0h Disable							Not Supported
1h External	1h Raw							Not Supported
1h External	2h Decrypt							Not Supported
1h External	3h Mixed							Not Supported
2h Encrypt	0h Disable	C/E	M	O[2]	P	P	P	
2h Encrypt	1h Raw							Not Supported
2h Encrypt	2h Decrypt	D/E	M	M[1]	P	P	P	
2h Encrypt	3h Mixed	D/E	M	M[1]	P	P	P	

Legend:

C = Cleartext read & write data
D = Decrypted read data
E = Encrypted write data
P = Prohibited
M= Mandatory
O = Optional
n/a = Not Applicable

Notes:

1. Pending ANSI approval.
2. Optional when SDK is not supported, SDK supported will become Mandatory.

Note – The references in the following paragraphs refer to SSC-3.

- If the SECURITY PROTOCOL or the SECURITY PROTOCOL SPECIFIC field is set to a reserved or unsupported value.

  The device server shall terminate the command with CHECK CONDITION status, with the sense key set to ILLEGAL REQUEST, and the additional sense code set to INVALID FIELD IN CDB.

- If the SPOUT command is sent to an older drive firmware that does not support the SPIN/SPOUT commands.

The drive shall terminate the command with CHECK CONDITION status, with the sense key set to ILLEGAL REQUEST, and the additional sense code set to INVALID COMMAND OPERATION CODE.

- If the SPOUT command is sent to a drive that has not been configured for DPKM support.

  The drive shall terminate the command with CHECK CONDITION status, with the sense key set to ILLEGAL REQUEST, and the additional sense code set to INVALID FIELD IN CDB (such as the Security Protocol field).

The PAGE LENGTH field specifies the number of bytes of parameter data to follow. If the page length value results in the truncation of any field the device server shall terminate the command with CHECK CONDITION status, with the sense key set to ILLEGAL REQUEST, and the additional sense code set to INVALID FIELD IN PARAMETER LIST.

The device server shall terminate the SECURITY PROTOCOL OUT command with CHECK CONDITION status, with the sense key set to ILLEGAL REQUEST, and the additional sense code set to INVALID FIELD IN PARAMETER DATA if the CEEM field is set to either 10b or 11b, and:

a. The DECRYPTION MODE field is set to DISABLE.

The device server shall terminate the command with CHECK CONDITION status, with the sense key set to ILLEGAL REQUEST and the additional sense key set to INVALID FIELD IN PARAMETER DATA if:

a. The ENCRYPTION MODE field is set to ENCRYPT;

b. The RDMC field is set to 10b or 11b; and

c. The RDMC_C field in the algorithm descriptor for the encryption algorithm selected by the value in the ALGORITHM INDEX field is set to 1h, 6h, or 7h.

- If the clear key on demount (CKOD) bit is set to *one* the physical device shall set the data encryption parameters to default values upon completion of a volume demount.

  If the CKOD bit is set to *zero*, the demounting of a volume CKOD shall not affect the data encryption parameters.

  If the bit is set to *one* and there is *no volume mounted* the device server shall terminate the command with CHECK CONDITION status and set the sense key to ILLEGAL REQUEST and the additional sense code to INVALID FIELD IN PARAMETER DATA.

- If the clear key on reservation preempt (CKORP) bit is set to *one*.

  The physical device shall set the data encryption parameters to default values when a persistent reservation is preempted (for example, a PERSISTENT RESERVE OUT command specifying a service action of PREEMPT or PREEMPT AND ABORT is processed).

  If the bit is set to *zero*, a preemption of a persistent reservation shall not affect the data encryption parameters.

If the bit is set to *one* and there is no persistent reservation in effect for the I_T nexus associated with the SECURITY PROTOCOL OUT command, the device server shall terminate the command with CHECK CONDITION status and set the sense key to ILLEGAL REQUEST and the additional sense code to INVALID FIELD IN PARAMETER DATA.

- If the clear key on reservation loss (CKORL) bit is set to *one* the physical device shall set the data encryption parameters to default values on a reservation loss.

  If the bit is set to *zero*, a reservation loss shall not affect the data encryption parameters.

  If the CKORL bit is set to *one* and there is *no reservation in effect* for the I_T nexus associated with the SECURITY PROTOCOL OUT command, the device server shall terminate the command with CHECK CONDITION status and set the sense key to ILLEGAL REQUEST and the additional sense code to INVALID FIELD IN PARAMETER DATA.

- If the ENCRYPTION MODE field is set to ENCRYPT and the KEY LENGTH field is set to zero.

  The device server shall terminate the command with CHECK CONDITION status, with the sense key set to ILLEGAL REQUEST, and the additional sense code set to INVALID FIELD IN PARAMETER DATA.

- If the DECRYPTION MODE field is set to DECRYPT or MIXED and the KEY LENGTH field is set to zero,

  The device server shall terminate the command with CHECK CONDITION status, with the sense key set to ILLEGAL REQUEST, and the additional sense code set to INVALID FIELD IN PARAMETER DATA.

- If the device server reports that it requires key-associated data (DKAD_C) from the application client and a Set Data Encryption page is processed that does not include a key-associated data descriptor.

  The device server shall terminate the command with CHECK CONDITION, with the sense key set to ILLEGAL REQUEST, and the additional sense code set to INCOMPLETE KEY-ASSOCIATED DATA SET.

- If a nonce value descriptor is included and the algorithm and the device server supports application client generated nonce values

  The value in the KEY DESCRIPTOR field shall be used as the nonce value for the encryption process.

- If a nonce value descriptor is included and the encryption algorithm or the device server does not support application client generated nonce values,

  The device server shall terminate the command with CHECK CONDITION, with the sense key set to ILLEGAL REQUEST, and the additional sense code set to INVALID FIELD IN PARAMETER LIST.

The device server shall terminate the command with CHECK CONDITION, with the sense key set to ILLEGAL REQUEST, and the additional sense code set to INVALID FIELD IN PARAMETER LIST if an A-KAD or M-KAD is included and:

a. The encryption algorithm specified by the ALGORITHM INDEX field does not support A-KAD or M-KAD.

If a device server processes a Set Data Encryption page with the ENCRYPTION MODE field set to DISABLE and DECRYPTION MODE field set to DISABLE or RAW, the physical device shall:

a. Release any resources that it had allocated to store data encryption parameters for the I_T nexus associated with the SECURITY PROTOCOL OUT command and shall change the contents of all memory containing a key value associated with the data encryption parameters that are released; and

b. Establish a unit attention condition, if the key actually changes, with the additional sense of DATA ENCRYPTION PARAMETERS CHANGED BY ANOTHER I_T NEXUS for all other I_T nexus that has its registered for encryption unit attentions state set to one (see 4.2.22.13) and is affected by the loss of the key, (i.e., any I_T nexus that is using a data encryption scope of PUBLIC and sharing the keys).

Send Diagnostic Command

The Send Diagnostic command provides a self-test that verifies the operation of the device. Any buffered write data and filemarks are written on the tape *before* this operation starts.

TABLE 3-170 Send Diagnostic Command

Byte	Bit 7	6	5	4	3	2	1	0
0	Operation Code (1Dh)							
1	Reserved			PF	RSVD	SelfTest	DevOfl	UnitOfl
2	Reserved							
3 thru 4	(MSB) Parameter List Length (LSB)							
5	Force Dump		Control Byte					

Parameter	Value
PF: Page Formatted	0 = Parameter data sent is not page formatted
	1 = Parameter data sent is page formatted
SelfTest: Self Test	1 = Perform default self test
DevOfl: Device Offline	0 = Diagnostics will not affect all logical units
UnitOfl: Unit Offline	0 = Diagnostics will not affect media loaded on logical unit
Parameter List Length:	Length in bytes of parameter data transferred to the drive.
Force Dump: Force dump	11b = Force a dump

Note – The command returns Good status if the test runs without errors, and Check Condition status if the test indicates a problem.

No parameter data is transferred when the Self Test option is set.

Note – In Force Dump mode, the drive will activate Tape Alert Flag 0x3A after the next IPL as a result of the force dump. This allows testing of the TA Flag: Firmware Failure.

Space Command

The Space command moves the logical position of the tape. Any buffered write data and filemarks are written on the tape *before* this operation starts. Note: The Space command does not always move tape.

TABLE 3-171 Space Command

Byte	Bit							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	Operation Code (11h)							
1	Reserved					Code		
2 thru 4	(MSB) Count (LSB)							
5	Control Byte							

Parameter	Value
Code	Type of space operation: 000b = Space blocks 001b = Space filemarks 011b = End-of-data (EOD)
Count	Number of blocks or filemarks to move. A negative count (two's complement notation) moves tape in reverse direction (toward BOT).

Notes:

1. A zero in the Count field does not move tape.
2. If a filemark is encountered during a Space Blocks command, Check Condition status is returned and the tape is positioned past the filemark. The Valid and Filemark bits in the sense data are set and the Information Bytes are set to the Count minus the actual number of blocks moved (not counting the filemark).
3. If an end-of-data is encountered during any space command (except space to end of data), Check Condition status is returned and the tape is positioned after the last valid record.

   For space blocks and filemarks, the Valid bit is set and the Information Bytes contains the Count minus the actual number of blocks or filemarks moved. The Sense Key is set to Blank Check. If the tape is positioned past LEOT, EOM is also set.
4. A forward space into PEOT returns Check Condition status and sets the EOM bit, and a sense key of Media Error. The information bytes contain the count minus the actual number of blocks or filemarks moved.

5. A reverse space operation into BOT returns Check Condition, sets the Valid and EOM bits, and sets the information bytes to the count minus the actual number of blocks or filemarks moved.
6. A space to end of data positions the tape after the last block or filemark.
7. A Check Condition caused by early termination of any space command does not result in a negative value in the information bytes.
8. A Reverse Space Operation of any type that does not complete successfully returns the count in the information bytes as a positive residual.

Test Unit Ready Command

The Test Unit Ready command checks if a device is loaded and ready to receive a command that accesses the media, such as Read or Write commands.

TABLE 3-172 Test Unit Ready Command

Byte	Bit 7	6	5	4	3	2	1	0
0	Operation Code (00h)							
1 thru 4	(MSB) Reserved (LSB)							
5	Control Byte							

Notes:

- Good status is returned if the tape drive is loaded and ready.
- Check Condition status with a sense key of Not Ready is returned if the tape drive is not loaded.
- Busy status is returned if a Rewind, Erase, Load/Unload, or Locate command with the immediate bit set was previously issued and the tape drive has not completed the command.

Verify Command

The Verify command reads one or more blocks of data from the tape without transferring the data to the host.

TABLE 3-173 Verify Command

Byte	Bit 7	6	5	4	3	2	1	0
0	Operation Code (13h)							
1	Reserved		VTE	VLBPM	VBF	Immed	BYTCMP	Fixed
2 thru 4	(MSB) Verification Length (LSB)							
5	SILI	Control Byte						

Parameter	Value
VTE	Verify To End-of-data 0 = Do not verify to end-of-data 1 = Verify to end-of-data If the verification fails the Information field in Status is zero The BYTCMP and VBF must be zero The Verification Length field is ignored
VLBPM	Verify Logical Block Protection Method 0 = Do not verify logical block protection mode 1 = Verify logical block protection mode Verify that each logical block uses the logical block protection method specified in the Control Data Protection mode page
VBF	Verify By Filemarks 0 = Do not verify by filemarks 1 = Verify by filemarks The Verification Length field contains the number of files to verify If the verification fails the Information field in Status is the number of files successfully verified, Read Position should be used to determine the record that failed The BYTCMP must be zero
Immed:	Immediate 0 = Return status when verify is completed
BYTCMP:	Byte compare 0 = Medium verification

Parameter	Value
Fixed	Block mode 0 = Variable block 1 = Fixed block
Verification Length	Number of bytes or blocks to verify
SILI: Suppress Illegal Length Indication	Suppress Illegal Length Indication 0 = Check condition status is returned if the record length does not match Verification Length. 1 = Return Check Condition status only when the actual record length is larger than Verification Length, and the Mode Sense block length field in not zero. **Note –** This option is not allowed if the fixed bit is 1.

Write Attribute Command

The Write Attribute command allows an application to write attribute values to medium auxiliary memory (MAM).

TABLE 3-174 Write Attribute Command

Byte	Bit 7	6	5	4	3	2	1	0
0	Operation Code (8Dh)							
1	Reserved							
2 thru 4	(MSB) Restricted (see SMC-2) (LSB)							
5	Logical Volume Number							
6	Reserved							
7	Partition Number							
8 thru 9	(MSB) Reserved (LSB)							
10 thru 13	(MSB) Parameter List Length (LSB)							
14	Reserved							
15	Control Byte							

Parameter	Value
Logical Volume Number	Only volume 0
Partition Number	Partition for attributes transferred
Parameter Length	Length of parameters transferred

TABLE 3-175 Write Attribute Parameter List Format

Byte	Bit 7	6	5	4	3	2	1	0
0 thru 3	(MSB) Parameter data Length (n-3) (LSB)							
4 thru n	Attribute 0							
	Attribute x							

The format of each MAM attribute is defined in TABLE 3-105.

Write Command

Parameter	Value
VTE:	Verify To End-of-data 0 = Do not verify to end-of-data 1 = Verify to end-of-data If the verification fails, the Information field in Status is zero. The BYTCMP and VBF must be zero. The Verification Length field is ignored.
VLBPM:	Verify Logical Block Protection Method 0 = Do not verify logical block protection mode. 1 = Verify logical block protection mode. Verify that each logical block uses the logical block protection method specified in the Control Data Protection mode page.
VBF:	Verify By Filemarks 0 = Do not verify by filemarks. 1 = Verify by filemarks. The Verification Length field contains the number of files to verify. If the verification fails the Information field in Status is the number of files successfully verified, Read Position should be used to determine the record that failed. The BYTCMP must be zero.
IMMED:	Immediate 0 = Return status when verify is completed
BYTCMP:	Byte compare 0 = Medium verification
FIXED	Indicates the block mode for data transfer: = 0 Variable block mode. Transfer Length is the number of bytes requested. = 1 Fixed block mode. Transfer Length is the number of blocks requested.
EXPECTED INITIAL REFERENCE TAG:	= The first logical block reference tag. Subsequent reference tag fields will be plus one.
EXPECTED APPLICATION TAG:	= Each logical block application tag field is set by the application client.
APPLICATION TAG MASK:	= This field contains a value that is a bit mask for enabling the checking of the logical block application tag field.

VERIFICATION LENGTH	= Number of bytes or blocks to verify
GRDC:	Guard Check 1 = Check the Guard field of the PI. 0 = Do not check the Guard field of the PI.
APPTC:	Application Tag Check 1 = Check the Application Tag field of the PI. 0 = Do not check the Application Tag field of the PI.
REFTC:	Reference Tag Check 1 = Check the Reference Tag field of the PI. 0 = Do not check the Reference Tag field of the PI.
SILI:	Suppress Illegal Length Indication = 0 Check condition status is returned if the record length does not match Transfer Length. ILI (Illegal Length Indication) and Valid bits in sense data are set. In variable block mode, the Information bytes are set to the Transfer Length minus the actual record size. In fixed block mode, Information bytes are set to the Transfer Length minus the number of blocks transferred, not including the incorrect length block. = 1 Return Check Condition status only when the actual record length is larger than transfer length, and the Mode Sense block length field in not zero. **Note –** This option is not allowed if the fixed bit is 1.

The Write command transfers one or more blocks of data from the host to tape.

TABLE 3-176 Write Command

Byte	Bit 7	6	5	4	3	2	1	0
0	Operation Code (0Ah)							
1	Reserved							Fixed
2 thru 4	(MSB) Transfer Length (LSB)							
5	Control Byte							

Parameter	Value
Fixed	Indicates the block mode for data transfer: 0 = Variable block mode. Transfer Length specifies the length of the block in bytes to be written. A single block is transferred from the initiator. 1 = Fixed block mode. Transfer Length specifies the number of blocks to be transferred to the device.
Transfer Length	Number of blocks or bytes requested

Notes:

1. Setting of the fixed bit is only allowed if the fixed block length is not zero. If block length is 0, the drive is in variable block mode. In fixed block mode, the record size is specified by the block length.

   The Mode Sense command reports the block length.

2. The Buffered Mode field of the Mode Select command controls when status is returned. If Buffered Mode is:

   0 = Status is returned after all data is written on the tape.
   1 = Status is returned after all data is in the buffer.

3. If the logical end-of-tape (LEOT) is encountered while writing on the tape, Check Condition status is returned and the end-of-medium (EOM) bit is set in sense data. The SEW bit in the mode sense device configuration page controls when data is written to the tape at LEOT.
4. If the physical end-of-tape (PEOT) is encountered, Check Condition status is returned and the sense key is set to Volume Overflow.
5. An un-correctable media error generates Check Condition status with a sense key of Media Error. Unwritten buffered records or filemarks are trapped in the buffer by this media error. Other tape motion commands are not allowed until the buffer is intentionally cleared by a Rewind or Unload command.
6. If a Write command returns Check Condition status, the valid bit in the Request Sense data is set.
7. The Request Sense information bytes are zeros if all data was written on tape. In variable block mode, the data indicates the total number of bytes not written on tape.
8. In fixed block mode, the information bytes return the total number of blocks not written on tape. A filemark is counted as one byte or block.
9. In buffered mode this total may include records from previous Write or Write Filemarks commands.
10. The error code is set to Deferred Error if records from other than this command remain in the buffer.

Data Integrity Validation—Write Operations

During write operations when DIV mode is enabled, all Write commands must have a transfer length that includes both the user data and the appended 4 bytes of Protection Information.

> **Note –** Use the Mode Select command Page 0Ah, Subpage F0h, to enable the DIV mode.

When in DIV mode the T10000 A and B tape drives strip away the PI data during transfer from the controller data buffer to the tape drive.

On T10000C and T10000D tape drives, the PI data is written to the media.

If an error occurs during Write operations, and the drive detects a miscompare, it reports it as a:

Check condition, with
Key = 04h (Hardware Error), and
ASC/ASCQ = 10 01h — Logical Block Guard Check Failed

This record is not written on the media.

Examples of when this may occur include:

- When transferring data for Write operations. As data passes from the Fibre Channel FC protocol chip (if it supports the current PI method) to the controller data buffer.
- If the drive is operating in Buffered mode, later when transferring the data to tape, the PI data is checked and a deferred error occurs.
- If the drive is operating in Non Buffered mode, when transferring the data from the controller data buffer to the tape, the PI data is checked.

For the Logical Block Guard Check error in buffered mode the error recovery procedure is as follows:

- On T10000A or B: the trapped write data must be released with a Rewind or Unload command, followed by repositioning of the tape to the last good record and retrying the failed write.
- On T10000C or T10000D: the trapped write data can also be released by doing a Space backwards then Space forwards, followed by retrying the failed record.

Write T10 PI (16) Command

The Write T10 PI (16) command (see TABLE 3-177) transfers one or more blocks of data from the host to tape. After successful completion of a write operation, the tape is positioned after the last block written. Each block transferred includes user data and protection information.

The Write T10 PI (16) command shall only be processed if T10 PI Protection Method is enabled and the LBP_W control bit is set (see Control Data Protection Mode Page)..

TABLE 3-177 Write T10 PI (16) Command

Byte	Bit 7	6	5	4	3	2	1	0
0	Operation Code (9Ah)							
1	GRDC	APPTC	REFTC	Reserved				FIXED
2	(MSB)							
3	EXPECTED INITIAL REFERENCE TAG							
4								
5								(LSB)
6	(MSB)	EXPECTED APPLICATION TAG						
7								(LSB)
8	(MSB)	APPLICATION TAG MASK						
9								(LSB)
10	(MSB)							
11	TRANSFER LENGTH							
12								
13								(LSB)
14	Reserved							
15	CONTROL							

Parameter	Value
GRDC:	Guard Check 1 = Check the Guard field of the PI. 0 = Do not check the Guard field of the PI.
APPTC:	Application Tag Check 1 = Check the Application Tag field of the PI. 0 = Do not check the Application Tag field of the PI.

REFTC:	Reference Tag Check 1 = Check the Reference Tag field of the PI. 0 = Do not check the Reference Tag field of the PI.
FIXED	Indicates the block mode for data transfer: = 0 Variable block mode. Transfer Length is the number of bytes requested. = 1 Fixed block mode. Transfer Length is the number of blocks requested.
EXPECTED INITIAL REFERENCE TAG:	= The first logical block reference tag. Subsequent reference tag fields will be plus one.
EXPECTED APPLICATION TAG:	= Each logical block application tag field is set by the application client.
APPLICATION TAG MASK:	= This field contains a value that is a bit mask for enabling the checking of the logical block application tag field.
TRANSFER LENGTH	Number of blocks or bytes requested.

Notes:

- Setting GRDC to 0 allows the customer write data to reside in the interface buffer with no protection! This operation is highly discouraged. The only valid setting of 0 is for diagnostic testing of Read T10PI error checking operations.
- If the device server detects a BLOCK APPLICATION TAG field set to FFFFh, then the device server disables checking of all other protection information for the associated protection information interval (single logical user data block) when reading from the medium.
- Setting of the Fixed bit is only allowed if the fixed block length is not zero. In fixed block mode, the record size is specified by the block length. The Mode Sense command reports the fixed block length.
- The physical T10PI record integrity can be verified with the Verify(6) and Verify(16) commands.
- See the Write Command description for additional notes.

Write Buffer Command

The Write Buffer command updates the functional microcode for the drive. The process of updating microcode is called a download.

A change in the initiator from one Write Buffer command to another during a download is interpreted as a new download process request and terminates the active process. This allows another initiator to download microcode if the first initiator goes down before completing its download request.

A successful download writes new microcode to memory and resets the tape drive after the final Write Buffer command completes.

A failure of the writing process causes the drive to retain the current version of the microcode.

A CRC check is performed over the entire microcode after the last command.

A Unit Attention condition is set for all initiators other than the initiator that requested the download with the additional sense code set to Microcode Has Been Changed.

Any buffered write data and filemarks are written on the tape *before* this operation starts.

TABLE 3-178 Write Buffer Command

Byte	Bit 7	6	5	4	3	2	1	0
0	Operation Code (3Bh)							
1	Reserved			Mode				
2	Buffer ID							
3 thru 5	(MSB) Buffer Offset (LSB)							
6 thru 8	(MSB) Parameter List Length (LSB)							
9	Control Byte							

Parameter	Value
Mode	Indicates the type of download: 06h = Download Microcode with Offsets Multiple transfers are required to download the microcode. The first Write Buffer command must contain data for the start of the image. Subsequent Write Buffer commands must transfer data in sequential order. This mode is used for all Write Buffer commands in a download except for the last one. 07h = Download Microcode with Offsets and Save This mode is used only once per download. It is used in conjunction with the Download Microcode with Offsets (110b) mode to indicate the last Write Buffer command of a download. This indicates that the download is finished and the microcode should be written to memory. A parameter list length of 0 is allowed for this mode. 0Ah = Write echo buffer
Buffer ID	Indicates the region of memory to be modified (must be 00h).
Buffer Offset	Offset from start of the buffer area (this field is ignored, except for Mode 0Ah on T10000D and newer drives).
Parameter List Length	Number of bytes to transfer.

Notes:

- The process of updating firmware is called a download. A successful download writes new firmware to memory and resets the tape drive after the final Write Buffer command completes. A failure of the writing process causes the drive to retain the current version of the firmware. A CRC check is performed over the entire download after the last command. A Unit Attention condition is set following a successful firmware download.
- The tape drive must be unloaded to perform this command.
- Blocks of firmware data must be transferred in sequential order. Each block except the last block transferred must be 262,144 bytes long. A parameter list length of 0 is allowed for mode 111b only.
- For compatibility with existing systems, mode field values 100b and 101b are accepted as equivalent to 110b and 111b. New implementations should not use 100b and 101b.
- The sequence of Write Buffer commands for a code download should be uninterrupted by other commands. It is suggested that the device be reserved during a code download.

Write Filemarks Command

The Write Filemarks command writes one or more filemarks on tape starting at the current logical position.

TABLE 3-179 Write Filemarks Command

Byte	Bit 7	6	5	4	3	2	1	0
0	Operation Code (10h)							
1	Reserved						WSmk	Immed
2 thru 4	(MSB) Filemark Count (LSB)							
5	Control Byte							

Parameter	Value
WSmk: Write Setmark bit	Write Setmark bit 0 = Write filemarks
Immed: Immediate mode	Immediate mode: 0 = Return status after filemarks are written on tape 1 = Return status after filemarks are in the buffer. **Note –** Must be in buffered mode if the immediate bit is set otherwise the command is rejected.
Transfer Length	Number of filemarks to write A Write Filemarks command with Transfer Length of 0, and Immed of 0 forces all buffered data to be written on tape. No additional filemarks are written and Good status is returned after all buffered data is on the tape.

Note – Refer to the Write command for information about media errors and logical end of tape (LEOT).

A

Data Integrity Validation

This appendix contains information about the Data Integrity Validation (DIV) feature for the T10000 tape drive. This feature is based on the ANSI T10 Technical Committee's implementation of the Data Integrity Field (DIF).

The terms DIV or DIF are also referred to as Protection Information (PI).

Data Integrity Validation

Oracle's StorageTek T10000-Series tape drive supports the Data Integrity Validation (DIV) feature. This feature provides end-to-end protection of user data during a transfer.

Initiators generate the Protection Information (PI) during a write operation. Any object associated with the I_T_L nexus[1] (such as the Host: application or host bus adapter; Target: controller or device) may check for this information.

Once the device receives the protection information (for example, written to tape), it keeps this information until overwritten. Any loss of power, hard reset, or a logical unit reset has no effect on the retention of this protection information.

Protection information is appended to the end of the record using the following format for the PI data.

Logical Block	Protection Information (4-byte CRC)

- The Logical Block field contains the original user data.
- The Protection Information field contains the CRC.

Note –

1. The capability of the drive to support DIV is advertised in Inquiry data and Mode Sense data.
2. To enable or disable DIV protection mode—use the Mode Select command.
3. Once enabling DIV mode; only the following commands are affected:

1. I_T_L nexus: A nexus is a connection that exists between an initiator, a target, and a logical unit. This is where one Initiator Port talks to one Target Port, addressing one LUN and together they execute one Task.

- Read (08h)
- Verify (13h)
- Write (0Ah)

4. The transfer lengths (CDB bytes 2-4) for these commands must include the additional 4 bytes of Protection Information.
5. During Reading or Writing with DIV mode enabled the Target returns a Check condition if a PI miscompare is detected

T10 PI Overview

The T10 PI model provides for protection of user data while it is being transferred between a sender and a receiver. Protection information can be generated by a Disk storage controller or it can be generated at the application layer and may be checked by any object associated with the I_T_L nexus (see SAM-4). Once received, protection information is retained (for example, written to medium, stored in non-volatile memory, or recalculated on read back) by the device server until it is overwritten. Power loss, hard reset, logical unit reset, and I_T nexus loss shall have no effect on the retention of protection information.

Support for protection information shall be indicated in the PROTECT bit in the standard INQUIRY data (see SPC-4).

Protection Information is also referred to as the Data Integrity Field (DIF) or Data Integrity Validation (DIV).

TABLE A-1 defines the placement of protection information in a logical block with a single protection information interval..

TABLE A-1 User Data and Protection Information Format

Byte	Bit 7	6	5	4	3	2	1	0
0	USER DATA							
...								
n - 1								
n	BLOCK GUARD							
n + 1								
n + 2	BLOCK APPLICATION TAG							
n + 3								
n + 4	BLOCK REFERENCE TAG							
...								
n + 7								

Each USER DATA field shall contain user data. The size of the user data field is defined in the Control Data Protection Mode Page.

Each BLOCK GUARD field contains a CRC (refer to SBC-3 r35 Clause 4.22.4, polynomium = 0x1_8BB7, seed = 0x0000, and no invert). Only the contents of the USER DATA field immediately preceding the BLOCK GUARD field. (that is, the user data between the preceding block reference tag, if any, and the current block guard) shall be used to generate and check the CRC contained in the BLOCK GUARD field.

Each BLOCK APPLICATION TAG field is set by the application client. If the device server detects a BLOCK APPLICATION TAG field set to FFFFh, then the device server disables checking of all other protection information for the associated protection information interval (single logical user data block) when reading from the medium. The contents of a BLOCK APPLICATION TAG field shall not be used to generate or check the CRC contained in the BLOCK GUARD field.

The first BLOCK REFERENCE TAG field of the first block shall be the value in the expected initial BLOCK REFERENCE TAG field of the command. Subsequent BLOCK REFERENCE TAG fields for a block shall be the previous block reference tag value plus one.

One or more sets of user data and protection information intervals may be combined into a single data stream (physical tape record) for tape write and read operations. The limiting factor is the maximum Block Length reported by the Mode Sense Block Descriptor Data, that is, a user data and protection information interval may not be split across two separate Host Write or Read operations.

These changes are in code release following the initial code release. Additional changes may be made in the future.

Reed-Solomon CRC

The following is a sample 'C program' to generate the Reed Solomon CRC[2] on an i386 class processor:

```
#include <unistd.h>
#include <stdio.h>
/*-----------------------------------------------------------------------
** INPUTS: crc - initial crc (0 for fresh) (i.e., seed)
** cnt - the number of data bytes to compute CRC for
** start - the starting address of the data bytes (e.g., data buffer)
** OUTPUTS: UINT32 - crc in big endian (MSB is first byte)
*/
uint32_t GenerateRSCRC(uint32_t crc, uint32_t cnt, const void *start)
{
static const uint32_t crcTable[256]=
{
0x00000000,0x38CF3801,0x70837002,0x484C4803,0xE01BE004,0xD8D4D805,
0x90989006,0xA857A807,0xDD36DD08,0xE5F9E509,0xADB5AD0A,0x957A950B,
0x3D2D3D0C,0x05E2050D,0x4DAE4D0E,0x7561750F,0xA76CA710,0x9FA39F11,
0xD7EFD712,0xEF20EF13,0x47774714,0x7FB87F15,0x37F43716,0x0F3B0F17,
0x7A5A7A18,0x42954219,0x0AD90A1A,0x3216321B,0x9A419A1C,0xA28EA21D,
0xEAC2EA1E,0xD20DD21F,0x53D85320,0x6B176B21,0x235B2322,0x1B941B23,
0xB3C3B324,0x8B0C8B25,0xC340C326,0xFB8FFB27,0x8EEE8E28,0xB621B629,
0xFE6DFE2A,0xC6A2C62B,0x6EF56E2C,0x563A562D,0x1E761E2E,0x26B9262F,
0xF4B4F430,0xCC7BCC31,0x84378432,0xBCF8BC33,0x14AF1434,0x2C602C35,
0x642C6436,0x5CE35C37,0x29822938,0x114D1139,0x5901593A,0x61CE613B,
0xC999C93C,0xF156F13D,0xB91AB93E,0x81D5813F,0xA6ADA640,0x9E629E41,
0xD62ED642,0xEEE1EE43,0x46B64644,0x7E797E45,0x36353646,0x0EFA0E47,
0x7B9B7B48,0x43544349,0x0B180B4A,0x33D7334B,0x9B809B4C,0xA34FA34D,
```

2. Reed–Solomon is an error-correcting code (ECC) that works by oversampling a polynomial constructed from the data. The polynomial is evaluated at several points, and these values are either sent or recorded. Reed–Solomon codes are used in a wide variety of applications for data transmission technologies.

```
0xEB03EB4E,0xD3CCD34F,0x01C10150,0x390E3951,0x71427152,0x498D4953,
0xE1DAE154,0xD915D955,0x91599156,0xA996A957,0xDCF7DC58,0xE438E459,
0xAC74AC5A,0x94BB945B,0x3CEC3C5C,0x0423045D,0x4C6F4C5E,0x74A0745F,
0xF575F560,0xCDBACD61,0x85F68562,0xBD39BD63,0x156E1564,0x2DA12D65,
0x65ED6566,0x5D225D67,0x28432868,0x108C1069,0x58C0586A,0x600F606B,
0xC858C86C,0xF097F06D,0xB8DBB86E,0x8014806F,0x52195270,0x6AD66A71,
0x229A2272,0x1A551A73,0xB202B274,0x8ACD8A75,0xC281C276,0xFA4EFA77,
0x8F2F8F78,0xB7E0B779,0xFFACFF7A,0xC763C77B,0x6F346F7C,0x57FB577D,
0x1FB71F7E,0x2778277F,0x51475180,0x69886981,0x21C42182,0x190B1983,
0xB15CB184,0x89938985,0xC1DFC186,0xF910F987,0x8C718C88,0xB4BEB489,
0xFCF2FC8A,0xC43DC48B,0x6C6A6C8C,0x54A5548D,0x1CE91C8E,0x2426248F,
0xF62BF690,0xCEE4CE91,0x86A88692,0xBE67BE93,0x16301694,0x2EFF2E95,
0x66B36696,0x5E7C5E97,0x2B1D2B98,0x13D21399,0x5B9E5B9A,0x6351639B,
0xCB06CB9C,0xF3C9F39D,0xBB85BB9E,0x834A839F,0x029F02A0,0x3A503AA1,
0x721C72A2,0x4AD34AA3,0xE284E2A4,0xDA4BDAA5,0x920792A6,0xAAC8AAA7,
0xDFA9DFA8,0xE766E7A9,0xAF2AAFAA,0x97E597AB,0x3FB23FAC,0x077D07AD,
0x4F314FAE,0x77FE77AF,0xA5F3A5B0,0x9D3C9DB1,0xD570D5B2,0xEDBFEDB3,
0x45E845B4,0x7D277DB5,0x356B35B6,0x0DA40DB7,0x78C578B8,0x400A40B9,
0x084608BA,0x308930BB,0x98DE98BC,0xA011A0BD,0xE85DE8BE,0xD092D0BF,
0xF7EAF7C0,0xCF25CFC1,0x876987C2,0xBFA6BFC3,0x17F117C4,0x2F3E2FC5,
0x677267C6,0x5FBD5FC7,0x2ADC2AC8,0x121312C9,0x5A5F5ACA,0x629062CB,
0xCAC7CACC,0xF208F2CD,0xBA44BACE,0x828B82CF,0x508650D0,0x684968D1,
0x200520D2,0x18CA18D3,0xB09DB0D4,0x885288D5,0xC01EC0D6,0xF8D1F8D7,
0x8DB08DD8,0xB57FB5D9,0xFD33FDDA,0xC5FCC5DB,0x6DAB6DDC,0x556455DD,
0x1D281DDE,0x25E725DF,0xA432A4E0,0x9CFD9CE1,0xD4B1D4E2,0xEC7EECE3,
0x442944E4,0x7CE67CE5,0x34AA34E6,0x0C650CE7,0x790479E8,0x41CB41E9,
0x098709EA,0x314831EB,0x991F99EC,0xA1D0A1ED,0xE99CE9EE,0xD153D1EF,
0x035E03F0,0x3B913BF1,0x73DD73F2,0x4B124BF3,0xE345E3F4,0xDB8ADBF5,
0x93C693F6,0xAB09ABF7,0xDE68DEF8,0xE6A7E6F9,0xAEEBAEFA,0x962496FB,
0x3E733EFC,0x06BC06FD,0x4EF04EFE,0x763F76FF
};
```

```
uint32_t i;
const uint8_t* d = start;
for ( i = 0; i < cnt; i++ )
{
crc = (crc << 8) ^ crcTable[*d ^ (crc >> 24)];
d++;
}
return crc;
}
```

```
/*****************************************/
/* Sample Reed Solomon Program */
/*****************************************/
#define FICON
#define INIT 0x00000000
int main(void)
{
uint32_t   crc;
uint32_t   cnt;
uint32_t   blk_len;
uint8_t   *blk_adr;
uint8_t  test_data[]=
{
#ifdef FICON
/* Test data, expected CRC is 0x61A56001 */
0xC8, 0xC4, 0xD9, 0xF1,
0xF0, 0xF0, 0xF0, 0xF0,
0xF0, 0xF0, 0xF0, 0xF0,
0xF0, 0xF0, 0xF0, 0xF0,
0xF0, 0xF0, 0xF0, 0xF0,
0xF0, 0xF0, 0xF0, 0xF0,
0xF0, 0xF0, 0xF0, 0xF0,
0xF0, 0xF0, 0xF0, 0xF0,
0xF0, 0xF0, 0xF0, 0xF0,
0xF0, 0xF0, 0xF0, 0xF0,
0xF0, 0xF0, 0xF0, 0xF0,
0xF0, 0xF0, 0xF0, 0xF0,
0xF0, 0xF0, 0xF0, 0xF0,
0xF0, 0xF0, 0xF0, 0xF0,
0xF0, 0xF0, 0xF0, 0xF0,
0xF0, 0xF0, 0xF0, 0xF0,
0xF0, 0xF0, 0xF0, 0xF0,
0xF0, 0xF0, 0xF0, 0xF0,
0xF0, 0xF0, 0xF0, 0xF0,
0xF0, 0xF0, 0xF0, 0xF0
#else
```

```
/* ASCII "12345678" Expected CRC is 0x03124E3E */
0x31, 0x32, 0x33, 0x34, 0x35, 0x36, 0x37, 0x38
/* Other odd byte size data crc's */
/* ASCII "123456789" Expected CRC is 0x4B4F673A */
/* ASCII "123456789A" Expected CRC is 0x25B15071 */
/* ASCII "123456789AB" Expected CRC is 0x5B929B1E */
#endif
};
printf("\nReed Solomon version 1.0, Demonstration Program.\n\n");
blk_len = sizeof(test_data);
printf("Sizeof test_data = %d \n", blk_len);
printf("Input String:\n");
for( cnt = 0; cnt < blk_len; cnt++ )
printf("%02X ", test_data[cnt]);
/* Compute Reed Solomon CRC */
blk_len = sizeof(test_data);
blk_adr = &test_data[0];
crc = INIT;
crc = GenerateRSCRC(crc, blk_len, blk_adr);
printf("\n\nReed Solomon Actual CRC = 0x%08X\n", crc);

#ifdef FICON
printf("\nExpected CRC = 0x61A56001\n\n");
#else
if(blk_len == 8)
printf("\nExpected CRC = 0x03124E3E\n\n");
#endif
return(0);
}
```

Vendor Unique SB-2 CRC

The following is a sample 'C program' to generate the SB-2 CRC on an i386 class processor.

FIGURE A-1 SB-2 CRC Program Example (Sheet 1 of 6)

```
/*********************************************************************
* File: sbbyte.c
* Description:  32bit implementation of the CRC32 LFSR.
* Copyright 2009 Sun Microsystems, Inc. All rights reserved.
*
* CRC algorithm was excerpted from "18. Roll Your Own Table-Driven
* Implementation" in the following document:
* "Everything you wanted to know about CRC algorithms, but were afraid to
* ask for fear that errors in your understanding might be detected."
*
*  Author : Ross N. Williams
*  E-Mail : ross@guest.adelaide.edu.au
*  Date : 19 August 1993
*  Version : 3.00
*
*  FTP: ftp.adelaide.edu.au/pub/rocksoft/crc_v3.txt
*  WWW: http://www.on.net/clients/rocksoft/ro ksoft/
*
*  Company : Rocksoft(tm) Pty Ltd
*  Snail : 16 Lerwick Avenue, Hazelwood Park 5066, Australia
*  Fax : +61 8 373-4911 (c/- Internode Systems Pty Ltd)
*  Phone : +61 8 379-9217 (10am to 10pm Adelaide Australia time)
*  Note : "Rocksoft" is a trademark of Rocksoft Pty Ltd, Australia
*
*  Status: Copyright (C) Ross Williams, 1993,1994,1995,1996. However,
*  permission is granted to make and distribute verbatim copies of this
*  document provided that this information block and copyright notice is
*  included. Also, the C code modules included in this document are fully
*  PUBLIC DOMAIN (PD).
*
*  Thanks: Thanks to Jean-loup Gailly (jloup@chorus.fr) and Mark Adler
*  (me@quest.jpl.nasa.gov) who both proof read this document and picked
*  out lots of nits as well as some big fat bugs.
*
*********************************************************************/
```

FIGURE A-1 SB-2 CRC Program Example (Sheet 2 of 6)

```
#include <unistd.h>
#include <stdio.h>
/*****************************************************************************/
/*                                                                           */
/* CRC LOOKUP TABLE                                                          */
/* ========================================                                  */
/* The following CRC lookup table was generated automagically               */
/* by the Rocksoft^tm Model CRC Algorithm Table Generation                  */
/* Program V1.0 using the following model parameters:                       */
/*                                                                           */
/*   Width  : 4 bytes.                                                       */
/*   Poly   : 0x04C11DB7L                                                    */
/*  Reverse : FALSE.                                                         */
/*                                                                           */
/* For more information on the Rocksoft^tm Model CRC Algorithm,             */
/* see the document titled "A Painless Guide to CRC Error                    */
/* Detection Algorithms" by Ross Williams                                    */
/* (ross@guest.adelaide.edu.au.). This document is likely to be             */
/* in the FTP archive "ftp.adelaide.edu.au/pub/rocksoft".                   */
/*                                                                           */
/*****************************************************************************/

unsigned long  crctable[256] =
{
0x00000000L, 0x04C11DB7L, 0x09823B6EL, 0x0D4326D9L,
0x130476DCL, 0x17C56B6BL, 0x1A864DB2L, 0x1E475005L,
0x2608EDB8L, 0x22C9F00FL, 0x2F8AD6D6L, 0x2B4BCB61L,
0x350C9B64L, 0x31CD86D3L, 0x3C8EA00AL, 0x384FBDBDL,
0x4C11DB70L, 0x48D0C6C7L, 0x4593E01EL, 0x4152FDA9L,
0x5F15ADACL, 0x5BD4B01BL, 0x569796C2L, 0x52568B75L,
0x6A1936C8L, 0x6ED82B7FL, 0x639B0DA6L, 0x675A1011L,
0x791D4014L, 0x7DDC5DA3L, 0x709F7B7AL, 0x745E66CDL,
0x9823B6E0L, 0x9CE2AB57L, 0x91A18D8EL, 0x95609039L,
0x8B27C03CL, 0x8FE6DD8BL, 0x82A5FB52L, 0x8664E6E5L,
0xBE2B5B58L, 0xBAEA46EFL, 0xB7A96036L, 0xB3687D81L,
0xAD2F2D84L, 0xA9EE3033L, 0xA4AD16EAL, 0xA06C0B5DL,
```

FIGURE A-1 SB-2 CRC Program Example (Sheet 3 of 6)

```
0xD4326D90L, 0xD0F37027L, 0xDDB056FEL, 0xD9714B49L,
0xC7361B4CL, 0xC3F706FBL, 0xCEB42022L, 0xCA753D95L,
0xF23A8028L, 0xF6FB9D9FL, 0xFBB8BB46L, 0xFF79A6F1L,
0xE13EF6F4L, 0xE5FFEB43L, 0xE8BCCD9AL, 0xEC7DD02DL,
0x34867077L, 0x30476DC0L, 0x3D044B19L, 0x39C556AEL,
0x278206ABL, 0x23431B1CL, 0x2E003DC5L, 0x2AC12072L,
0x128E9DCFL, 0x164F8078L, 0x1B0CA6A1L, 0x1FCDBB16L,
0x018AEB13L, 0x054BF6A4L, 0x0808D07DL, 0x0CC9CDCAL,
0x7897AB07L, 0x7C56B6B0L, 0x71159069L, 0x75D48DDEL,
0x6B93DDDBL, 0x6F52C06CL, 0x6211E6B5L, 0x66D0FB02L,
0x5E9F46BFL, 0x5A5E5B08L, 0x571D7DD1L, 0x53DC6066L,
0x4D9B3063L, 0x495A2DD4L, 0x44190B0DL, 0x40D816BAL,
0xACA5C697L, 0xA864DB20L, 0xA527FDF9L, 0xA1E6E04EL,
0xBFA1B04BL, 0xBB60ADFCL, 0xB6238B25L, 0xB2E29692L,
0x8AAD2B2FL, 0x8E6C3698L, 0x832F1041L, 0x87EE0DF6L,
0x99A95DF3L, 0x9D684044L, 0x902B669DL, 0x94EA7B2AL,
0xE0B41DE7L, 0xE4750050L, 0xE9362689L, 0xEDF73B3EL,
0xF3B06B3BL, 0xF771768CL, 0xFA325055L, 0xFEF34DE2L,
0xC6BCF05FL, 0xC27DEDE8L, 0xCF3ECB31L, 0xCBFFD686L,
0xD5B88683L, 0xD1799B34L, 0xDC3ABDEDL, 0xD8FBA05AL,
0x690CE0EEL, 0x6DCDFD59L, 0x608EDB80L, 0x644FC637L,
0x7A089632L, 0x7EC98B85L, 0x738AAD5CL, 0x774BB0EBL,
0x4F040D56L, 0x4BC510E1L, 0x46863638L, 0x42472B8FL,
0x5C007B8AL, 0x58C1663DL, 0x558240E4L, 0x51435D53L,
0x251D3B9EL, 0x21DC2629L, 0x2C9F00F0L, 0x285E1D47L,
0x36194D42L, 0x32D850F5L, 0x3F9B762CL, 0x3B5A6B9BL,
0x0315D626L, 0x07D4CB91L, 0x0A97ED48L, 0x0E56F0FFL,
0x1011A0FAL, 0x14D0BD4DL, 0x19939B94L, 0x1D528623L,
```

FIGURE A-1 SB-2 CRC Program Example (Sheet 4 of 6)

```
0xF12F560EL, 0xF5EE4BB9L, 0xF8AD6D60L, 0xFC6C70D7L
0xE22B20D2L, 0xE6EA3D65L, 0xEBA91BBCL, 0xEF68060BL,
0xD727BBB6L, 0xD3E6A601L, 0xDEA580D8L, 0xDA649D6FL,
0xC423CD6AL, 0xC0E2D0DDL, 0xCDA1F604L, 0xC960EBB3L,
0xBD3E8D7EL, 0xB9FF90C9L, 0xB4BCB610L, 0xB07DABA7L,
0xAE3AFBA2L, 0xAAFBE615L, 0xA7B8C0CCL, 0xA379DD7BL,
0x9B3660C6L, 0x9FF77D71L, 0x92B45BA8L, 0x9675461FL,
0x8832161AL, 0x8CF30BADL, 0x81B02D74L, 0x857130C3L,
0x5D8A9099L, 0x594B8D2EL, 0x5408ABF7L, 0x50C9B640L,
0x4E8EE645L, 0x4A4FFBF2L, 0x470CDD2BL, 0x43CDC09CL,
0x7B827D21L, 0x7F436096L, 0x7200464FL, 0x76C15BF8L,
0x68860BFDL, 0x6C47164AL, 0x61043093L, 0x65C52D24L,
0x119B4BE9L, 0x155A565EL, 0x18197087L, 0x1CD86D30L,
0x029F3D35L, 0x065E2082L, 0x0B1D065BL, 0x0FDC1BECL,
0x3793A651L, 0x3352BBE6L, 0x3E119D3FL, 0x3AD08088L,
0x2497D08DL, 0x2056CD3AL, 0x2D15EBE3L, 0x29D4F654L,
0xC5A92679L, 0xC1683BCEL, 0xCC2B1D17L, 0xC8EA00A0L,
0xD6AD50A5L, 0xD26C4D12L, 0xDF2F6BCBL, 0xDBEE767CL,
0xE3A1CBC1L, 0xE760D676L, 0xEA23F0AFL, 0xEEE2ED18L,
0xF0A5BD1DL, 0xF464A0AAL, 0xF9278673L, 0xFDE69BC4L,
0x89B8FD09L, 0x8D79E0BEL, 0x803AC667L, 0x84FBDBD0L,
0x9ABC8BD5L, 0x9E7D9662L, 0x933EB0BBL, 0x97FFAD0CL,
0xAFB010B1L, 0xAB710D06L, 0xA6322BDFL, 0xA2F33668L,
0xBCB4666DL, 0xB8757BDAL, 0xB5365D03L, 0xB1F740B4L
};
/*****************************************************************/
/*                End of CRC Lookup Table                       */
/*****************************************************************/
```

```
#define NAME            "CRC-32"
#define WIDTH           32
#define POLY            0x04C11DB7
#define INIT            0xFFFFFFFF
#define INIT_REFLECTED  0xFFFFFFFF
#define REFIN           FALSE
#define REFOUT          FALSE
#define XOROUT          0XFFFFFFFF
#define CHECK           0xFC891918
```

FIGURE A-1 SB-2 CRC Program Example (Sheet 5 of 6)

```
/* NOTE: The CHECK is for the standard 9 byte test data of
*  ASCII string "123456789"
*/
#define FICON

/*****************************************************************************
*
* Function:   Main
* Purpose:    Calculate the FICON (Single Byte) CRC32
* Args:       none
* Return Value:  none
* Remarks:
* CRC32 Generator Polinomial:
* 0x104C11DB7
*
* x^0+x^1+x^2+x^4+x^5+x^7+x^8+x^10+x^11+x^12+x^16+x^22+x^23+x^26+x^32
*
* The CRC 32 polinomial is a linear feedback shift register that will
* generate a Maximal Length Sequence, implemented here using a lookup
* table, to reduce the number of shift and XOR operations.
*
****************************************************************************/
int main(void)
{
uint32_t   crc;
uint32_t   cnt;
uint32_t   blk_len;
uint8_t    *blk_adr;
uint8_t  test_data[]=
{
```

FIGURE A-1 SB-2 CRC Program Example (Sheet 6 of 6)

```
#ifdef FICON
/* Test data, expected CRC is 0x1DC41771 */
0x00, 0x00, 0x00, 0xC7,
0x00, 0x00, 0x00, 0xC8
#else
/* ASCII "123456789" Expected CRC is 0xFC891918 */
0x31, 0x32, 0x33, 0x34, 0x35, 0x36, 0x37, 0x38, 0x39
#endif
};
printf("\nCrc32 ver. 1.0, 32bit CRC32 Demonstration Program.\n\n");
blk_len = sizeof(test_data);
printf("Sizeof test_data = %d \n", blk_len);
printf("Input String:\n");
for(cnt = 0; cnt < blk_len; cnt++)
printf("%02X ", test_data[cnt]);
/* Do Non Reflected CRC */
blk_len = sizeof(test_data);
blk_adr = &test_data[0];
crc = INIT;
while (blk_len--)
crc = crctable[((crc>>24) ^ *blk_adr++) & 0xFF] ^ (crc << 8);
crc = crc ^ XOROUT;
printf("\n\nNon Reflected Actual CRC32 = 0x%08X\n", crc);
#ifdef FICON
printf("\nExpected CRC32 = 0x1DC41771\n");
#else
printf("\nExpected CRC32 = 0xFC891918\n");
#endif
return(0);
}
/******************************************************************/
```

Vendor Unique iSCSI CRC32C

Build Instructions

The following instructions must be put into a Makefile. Include all of the "C" code identified in all sections below into a file called main.c and put the SPARC assembler in a file called crc32.il. Then run "make".

```
MACH:sh = uname -p

# SunOS
i386_CFLAGS =
sparc_CFLAGS = crc32.il

# Linux
x86_64_CFLAGS =

CFLAGS = $($(MACH)_CFLAGS)

main : main.c
   cc $(CFLAGS) -o main main.c
```

Main Function and Defines

```
#include <unistd.h>
#include <stdio.h>
#include <stdlib.h>
#include <string.h>

#if defined(__sparc)
#define CRC32C_SIZE       8     /* 8 data bytes per cpu crc inst */
#else
#if defined(__amd64) || defined(__x86_64)
#define CRC32C_INST        "0x48, " /* byte code for 64-bit code */
#define CRC32C_SIZE       8     /* 8 data bytes per cpu crc inst */
#else
#define CRC32C_INST                  /* no inst byte code for 32-
bit code */
#define CRC32C_SIZE       4     /* 4 data bytes per cpu crc inst */
#endif
#define  CRC32C_ALIGN        (CRC32C_SIZE - 1)

#define   CRC32C_XOR 0xFFFFFFFF     /* ending polynomial crc xor
value */
#define    CRC32C_INIT  0xFFFFFFFF
#define    CRC32C_LEN  4              /* crc length in bytes */

#if defined(__sun__) || defined(__SunOS)
/*******************/
/* Solaris ONLY */
```

```
/*******************/
#if defined(__sparc)

#include <sys/auxv.h>           /* getisax() */
#include <sys/auxv_SPARC.h>     /* crc32c instruction support bit
*/
#include <sys/archsystm.h>
#include <sys/fsr.h>

extern void _t4_crc32c(uint64_t *,  uint64_t *, int);
#else
#include <sys/auxv.h>           /* getisax() */
#include <sys/auxv_386.h>       /* AV_386_SSE4_2 bit */
#endif
/************************/
/* End Solaris ONLY */
/************************/
#else
/************************/
/* Linux ONLY */
/************************/
typedef u_int8_t uchar_t;
typedef u_int32_t uint32_t;
typedef u_int32_t uint_t;
typedef u_int8_t uint8_t;
typedef u_int64_t uint64_t;

static inline void cpuid(uint_t info[4], uint_t function)
{
   __asm__ __volatile__ ("cpuid":
        "=a" (info[0]),/* ax */
        "=b" (info[1]),/* bx */
        "=c" (info[2]),/* cx */
        "=d" (info[3]) :/* dx */
        "a" (function)
   );
}

static int hasSSE42(void)
{
        int sse42 = 0;
        uint_t info[4];
        cpuid(info, 0x000000000);
        int ids = info[0];

        if (ids >= 1) {
                cpuid(info, 0x00000001);
                sse42 = (info[2] & ((int)1 << 20)) != 0;
        }
        return sse42;
}
/************************/
```

```
/* End Linux ONLY */
/*************************/
#endif

void add_crc32c(char *buf, int len);
uint32_t calc_crc32c_sw(char *buf, int len, uint32_t crc);
uint32_t calc_crc32c_sparc(char *buf, int len, uint32_t crc);
uint32_t calc_crc32c_intel(char *buf, int len, uint32_t crc);

int main(int argc, char **argv)
{
   char *buf;
   const int blksz = 2097152;
   int i;

   /* allocate 2MB block plus 4 bytes for crc */
   buf = (char *)malloc(blksz + 4);
   for (i = 0; i < blksz; i++) {
      buf[i] = 1;
   }
   /* calculate data crc and insert crc at end of data */
   add_crc32c(buf, blksz);
   printf("crc32c: %02x%02x%02x%02x\n",
        (uchar_t)buf[blksz],
        (uchar_t)buf[blksz+1],
        (uchar_t)buf[blksz+2],
        (uchar_t)buf[blksz+3]);
}

void add_crc32c(char *buf, int len)
{
        /* Where buf is the user data buffer address. Buffer must
contain extra 4 bytes for CRC.*/
        /* Where len is the length of the user data in bytes. */

        uint32_t crc;

#if defined(__sun__) || defined(__SunOS)
/*******************/
/* Solaris ONLY */
/*******************/
        uint_t  ui = 0;

        (void) getisax(&ui, 1);


#ifdef  __sparc
        if (ui & AV_SPARC_CRC32C) {
                /* use sparc crc instruction */
           crc = calc_crc32c_sparc(buf, len, CRC32C_INIT);
#else
        if (ui & AV_386_SSE4_2) {
                /* use intel crc instruction */
```

```
            crc = calc_crc32c_intel(buf, len, CRC32C_INIT);
#endif
        } else {
                /* use software crc */
            crc = calc_crc32c_sw(buf, len, CRC32C_INIT);
        }
/************************/
/* End Solaris ONLY */
/************************/
#else
/*******************/
/* Linux ONLY */
/*******************/
   if (hasSSE42()) {
                /* use intel crc instruction */
      crc = calc_crc32c_intel(buf, len, CRC32C_INIT);
   } else {
                /* use software crc */
      crc = calc_crc32c_sw(buf, len, CRC32C_INIT);
   }
            /* printf("hasSSE42 %d\n", hasSSE42()); */
/************************/
/* End Linux ONLY */
/************************/
#endif

        /* add crc to tape block in big endian format */
#if defined(__sparc)
        buf[len] = (uchar_t)(crc);
        buf[len+1] = (uchar_t)(crc >> 8);
        buf[len+2] = (uchar_t)(crc >> 16);
        buf[len+3] = (uchar_t)(crc >> 24);
#else
        buf[len] = (uchar_t)(crc >> 24);
        buf[len+1] = (uchar_t)(crc >> 16);
        buf[len+2] = (uchar_t)(crc >> 8);
        buf[len+3] = (uchar_t)(crc);
#endif
}
```

Software Method

```
/****************************************************************
*
*    CRC LOOKUP TABLE
*
****************************************************************/


uint32_t crc32c_table[256] =
{
```

```
0x00000000, 0xF26B8303, 0xE13B70F7, 0x1350F3F4,
0xC79A971F, 0x35F1141C, 0x26A1E7E8, 0xD4CA64EB,
0x8AD958CF, 0x78B2DBCC, 0x6BE22838, 0x9989AB3B,
0x4D43CFD0, 0xBF284CD3, 0xAC78BF27, 0x5E133C24,
0x105EC76F, 0xE235446C, 0xF165B798, 0x030E349B,
0xD7C45070, 0x25AFD373, 0x36FF2087, 0xC494A384,
0x9A879FA0, 0x68EC1CA3, 0x7BBCEF57, 0x89D76C54,
0x5D1D08BF, 0xAF768BBC, 0xBC267848, 0x4E4DFB4B,
0x20BD8EDE, 0xD2D60DDD, 0xC186FE29, 0x33ED7D2A,
0xE72719C1, 0x154C9AC2, 0x061C6936, 0xF477EA35,
0xAA64D611, 0x580F5512, 0x4B5FA6E6, 0xB93425E5,
0x6DFE410E, 0x9F95C20D, 0x8CC531F9, 0x7EAEB2FA,
0x30E349B1, 0xC288CAB2, 0xD1D83946, 0x23B3BA45,
0xF779DEAE, 0x05125DAD, 0x1642AE59, 0xE4292D5A,
0xBA3A117E, 0x4851927D, 0x5B016189, 0xA96AE28A,
0x7DA08661, 0x8FCB0562, 0x9C9BF696, 0x6EF07595,
0x417B1DBC, 0xB3109EBF, 0xA0406D4B, 0x522BEE48,
0x86E18AA3, 0x748A09A0, 0x67DAFA54, 0x95B17957,
0xCBA24573, 0x39C9C670, 0x2A993584, 0xD8F2B687,
0x0C38D26C, 0xFE53516F, 0xED03A29B, 0x1F682198,
0x5125DAD3, 0xA34E59D0, 0xB01EAA24, 0x42752927,
0x96BF4DCC, 0x64D4CECF, 0x77843D3B, 0x85EFBE38,
0xDBFC821C, 0x2997011F, 0x3AC7F2EB, 0xC8AC71E8,
0x1C661503, 0xEE0D9600, 0xFD5D65F4, 0x0F36E6F7,
0x61C69362, 0x93AD1061, 0x80FDE395, 0x72966096,
0xA65C047D, 0x5437877E, 0x4767748A, 0xB50CF789,
0xEB1FCBAD, 0x197448AE, 0x0A24BB5A, 0xF84F3859,
0x2C855CB2, 0xDEEEDFB1, 0xCDBE2C45, 0x3FD5AF46,
0x7198540D, 0x83F3D70E, 0x90A324FA, 0x62C8A7F9,
0xB602C312, 0x44694011, 0x5739B3E5, 0xA55230E6,
0xFB410CC2, 0x092A8FC1, 0x1A7A7C35, 0xE811FF36,
0x3CDB9BDD, 0xCEB018DE, 0xDDE0EB2A, 0x2F8B6829,
0x82F63B78, 0x709DB87B, 0x63CD4B8F, 0x91A6C88C,
0x456CAC67, 0xB7072F64, 0xA457DC90, 0x563C5F93,
0x082F63B7, 0xFA44E0B4, 0xE9141340, 0x1B7F9043,
0xCFB5F4A8, 0x3DDE77AB, 0x2E8E845F, 0xDCE5075C,
0x92A8FC17, 0x60C37F14, 0x73938CE0, 0x81F80FE3,
0x55326B08, 0xA759E80B, 0xB4091BFF, 0x466298FC,
0x1871A4D8, 0xEA1A27DB, 0xF94AD42F, 0x0B21572C,
0xDFEB33C7, 0x2D80B0C4, 0x3ED04330, 0xCCBBC033,
0xA24BB5A6, 0x502036A5, 0x4370C551, 0xB11B4652,
0x65D122B9, 0x97BAA1BA, 0x84EA524E, 0x7681D14D,
0x2892ED69, 0xDAF96E6A, 0xC9A99D9E, 0x3BC21E9D,
```

```
        0xEF087A76, 0x1D63F975, 0x0E330A81, 0xFC588982,
        0xB21572C9, 0x407EF1CA, 0x532E023E, 0xA145813D,
        0x758FE5D6, 0x87E466D5, 0x94B49521, 0x66DF1622,
        0x38CC2A06, 0xCAA7A905, 0xD9F75AF1, 0x2B9CD9F2,
        0xFF56BD19, 0x0D3D3E1A, 0x1E6DCDEE, 0xEC064EED,
        0xC38D26C4, 0x31E6A5C7, 0x22B65633, 0xD0DDD530,
        0x0417B1DB, 0xF67C32D8, 0xE52CC12C, 0x1747422F,
        0x49547E0B, 0xBB3FFD08, 0xA86F0EFC, 0x5A048DFF,
        0x8ECEE914, 0x7CA56A17, 0x6FF599E3, 0x9D9E1AE0,
        0xD3D3E1AB, 0x21B862A8, 0x32E8915C, 0xC083125F,
        0x144976B4, 0xE622F5B7, 0xF5720643, 0x07198540,
        0x590AB964, 0xAB613A67, 0xB831C993, 0x4A5A4A90,
        0x9E902E7B, 0x6CFBAD78, 0x7FAB5E8C, 0x8DC0DD8F,
        0xE330A81A, 0x115B2B19, 0x020BD8ED, 0xF0605BEE,
        0x24AA3F05, 0xD6C1BC06, 0xC5914FF2, 0x37FACCF1,
        0x69E9F0D5, 0x9B8273D6, 0x88D28022, 0x7AB90321,
        0xAE7367CA, 0x5C18E4C9, 0x4F48173D, 0xBD23943E,
        0xF36E6F75, 0x0105EC76, 0x12551F82, 0xE03E9C81,
        0x34F4F86A, 0xC69F7B69, 0xD5CF889D, 0x27A40B9E,
        0x79B737BA, 0x8BDCB4B9, 0x988C474D, 0x6AE7C44E,
        0xBE2DA0A5, 0x4C4623A6, 0x5F16D052, 0xAD7D5351
};


uint32_t
calc_crc32c_sw(char *buf, int len, uint32_t crc)
{
        uint32_t i;
        uint8_t *blk_adr = (uint8_t *)buf;

#if defined(__sparc)
        crc = (crc & 0xff) << 24 |
             (crc & 0xff00) << 8 |
             (crc & 0xff0000) >> 8 |
             (crc & 0xff000000) >> 24;
#endif

        for (i = 0; i < len; i++) {
   if ((uchar_t)*blk_adr != 1) {
      printf("corrupt at %d\n", i);
      exit(1);
   }
```

```
                crc = crc32c_table[(crc ^ *blk_adr++) & 0xFF] ^
(crc >> 8);
        }

#if defined(__sparc)
        crc = (crc & 0xff000000) >> 24 |
            (crc & 0xff0000) >> 8 |
            (crc & 0xff00) << 8 |
            (crc & 0xff) << 24;
#endif

        return (crc ^ CRC32C_XOR);
}
```

Hardware Assist

Intel Nehalem

```
#if defined(__i386) || defined(__amd64) || defined(__x86_64)
/* Common Solaris and Linux code */
uint32_t
calc_crc32c_intel(char *buf, int len, uint32_t crc)
{
        uint8_t *addr = (uint8_t *)buf;
        int i;
        int align;
        int length;

        /* calc crc for unaligned memory addresses */
        if ((align = ((intptr_t)addr & CRC32C_ALIGN)) > 0) {
                align = CRC32C_SIZE - align;
                align = (align > len) ? len : align;
                for (i = 0; i < align; i++) {
                        __asm__ __volatile__(
                            /* "crc32 r32, r/m8" */
                            ".byte 0xF2, 0x0F, 0x38, 0xF0, 0xF1"
                            : "=S"(crc)
                            : "0"(crc), "c"(*addr));
                        addr++;
                }
                len -= align;
        }

        /* calc crc for word aligned memory addresses */
```

```
        if ((length = len / CRC32C_SIZE) > 0) {
#if defined(__amd64) || defined(__x86_64)
                uint64_t *data = (uint64_t *)addr;
#else
                uint32_t *data = (uint32_t *)addr;
#endif

                for (i = 0; i < length; i++) {
                        __asm__ __volatile__(
                            /* "crc32 r32, r/m32" or "crc32 r32,
r/m64" */
                            ".byte 0xF2, " CRC32C_INST
                            "0x0F, 0x38, 0xF1, 0xF1"
                            : "=S"(crc)
                            : "0"(crc), "c"(*data));
                        data++;
                }
                addr = (uint8_t *)data;
                len -= length * CRC32C_SIZE;
        }

        /* calc crc for remaining data */
        for (i = 0; i < len; i++) {
                __asm__ __volatile__(
                    /* "crc32 r32, r/m8" */
                    ".byte 0xF2, 0x0F, 0x38, 0xF0, 0xF1"
                    : "=S"(crc)
                    : "0"(crc), "c"(*addr));
                addr++;
        }

        return (crc ^ CRC32C_XOR);
}
#endif
```

Sparc (T4 Minimum)

```
#if defined(__sparc)
uint32_t
calc_crc32c_sparc(char *buf, int len, uint32_t crc)
{
    uint8_t *addr = (uint8_t *)buf;
```

```
        int align;
        int length;

        /* calc crc for unaligned memory addresses */
        if ((align = ((intptr_t)addr & CRC32C_ALIGN)) > 0) {
                align = CRC32C_SIZE - align;
                align = (align > len) ? len : align;
                crc = calc_crc32c_sw((char *)addr, align, crc);
                crc ^= CRC32C_XOR;
                addr = &addr[align];
                len -= align;
        }

        /* calc crc for word aligned memory addresses */
        if ((length = len / CRC32C_SIZE) > 0) {
                uint64_t lcrc = crc;
                uint64_t *data = (uint64_t *)addr;

                _t4_crc32c(&lcrc, data, length);

                crc = (uint32_t)lcrc;
                addr = (uint8_t *)&data[length];
                len -= length * CRC32C_SIZE;
        }

        /* calculate crc for remaining data */
        if (len > 0) {
                crc = calc_crc32c_sw((char *)addr, len, crc);
                return (crc);
        }

        return (crc ^ CRC32C_XOR);
}
#endif
```

```
/*
 * Put the following SPARC CRC32C assembler into a file named crc32.il.
 */
/*
 * CDDL HEADER START
 *
 * The contents of this file are subject to the terms of the
 * Common Development and Distribution License (the "License").
 * You may not use this file except in compliance with the License.
 *
 * You can obtain a copy of the license at pkg/OPENSOLARIS.LICENSE
 * or http://www.opensolaris.org/os/licensing.
 * See the License for the specific language governing permissions
 * and limitations under the License.
 *
 * When distributing Covered Code, include this CDDL HEADER in each
 * file and include the License file at pkg/OPENSOLARIS.LICENSE.
 * If applicable, add the following below this CDDL HEADER, with the
 * fields enclosed by brackets "[]" replaced with your own identifying
 * information: Portions Copyright [yyyy] [name of copyright owner]
 *
 * CDDL HEADER END
 */

/*
 * Copyright (c) 2011, 2014, Oracle and/or its affiliates. All rights reserved.
 */


    inline _t4_crc32c,3
    rd%fprs, %o3 ! backup fprs register
    wr %g0, 0x4, %fprs ! fprs.fef = 1
    ldd     [%o0],%f0
1:
```

```
        ldd      [%o1 + 0x000],%f2
!        crc32c  %f0,%f2,%f0
        .word    0x81b028e2
        subcc%o2, 1, %o2
        bne,a1b
        add%o1, 0x08, %o1

        std      %f0,[%o0]
        wr%o3, 0, %fprs
!       membar #Sync
        .end
```

B

Media Validation

The Fibre Channel Reference Manual Media Validation Section is intended for software application developers, and operating system or driver developers implementing Media Validation on Fibre Channel StorageTek T10000 Tape Drives.

The Media Validation feature is available only on the T10000C and T10000D drive. Where information changes, the following is used to identify them.

Media Validation Overview

The Media Validation feature is used to determine the condition of tape cartridges and tape drives. A vendor unique Verify(16) command is used to start and stop the different types of Media Validation. A Request Sense command can be used to monitor the progress of a Media Validation.

SCSI Verify Command (16 Byte)

The SCSI Verify command is a vendor unique command used to perform StorageTek T10000 Media Validation using the Fibre Channel Interface of the StorageTek T10000C and T10000D tape drives.

The tape drive will respond with status immediately. This allows the application to issue Request Sense commands to monitor progress of the media validation. Most other commands will return busy status while the media validation is running..

TABLE B-1 CDB for SCSI Verify Command

Byte	Bit 7	6	5	4	3	2	1	0
0	Operation Code (8Fh)							
1	Reserved		VTE	VLBPM	VBF	IMMED	BYTCMP	Fixed
2			SSP	STOP	RBMIR	MedStat	LAST	NonDIV
3	Partition							
4 thru 11	(MSB) Logical Object Identifier (LSB)							
12 thru 14	(MSB) Verification Length (LSB)							
15	MedVal	Reserved	Control					

Parameter	Value/Description
Operation Code	8Fh
VTE	1b Verify to EOD on last partition
VLBPM	0b
VBF	0b
IMMED	1b Status returned when command starts
BYTCMP	0b
Fixed	0b
SSP	0b Do not start from specified position 1b Start from Specified Position
STOP	0b Perform Media Validation 1b Stop Media Validation
RBMIR	1b Rebuild MIR starting at MIR invalid point
MedStat	0b VolStat verify 1b MediaStat verify

LAST	0b Start at logical object identifier position 1b Start at last verified position
NonDIV	0b DIV verify 1b Non DIV verify
Partition	00h
Logical Object Identifier	0000000000000000h
Verification Length	000000h
MedVal	1b Vendor unique Media Validation verify command

SCSI Verify Command Table: Verify Options

TABLE B-2 SCSI Verify Command Table: Verify Options

starting from / SCSI Verify byte	Complete Verify						Standard Verify
	with DIV checking			without DIV checking			
	BOT	resume point	specified position*	BOT	resume point	specified position*	
0	8Fh	8Fh	8Fh	8Fh	8Fh	8Fh	8Fh
1	24h	24h	24h	24h	24h	24h	24h
2	00h	02h	20h	01h	03h	21h	04h
3	00h	00h	Partition #	00h	00h	Partition #	00h
4	00h	00h	Record # (byte 4-11)	00h	00h	Record # (byte 4-11)	00h
5	00h	00h		00h	00h		00h
6	00h	00h		00h	00h		00h
7	00h	00h		00h	00h		00h
8	00h	00h		00h	00h		00h
9	00h	00h		00h	00h		00h
10	00h	00h		00h	00h		00h
11	00h	00h		00h	00h		00h
12	00h	00h	00h	00h	00h	00h	00h
13	00h	00h	00h	00h	00h	00h	00h
14	00h	00h	00h	00h	00h	00h	00h
15	80h	80h	80h	80h	80h	80h	80h

SCSI Verify Command Table: Other Functions

TABLE B-3 SCSI Verify Command Table: Other Functions

SCSI Verify Byte	Stop Media Validation	MIR Rebuild
0	8Fh	8Fh
1	20h	24h
2	10h	08h
3	00h	00h
4	00h	00h
5	00h	00h
6	00h	00h
7	00h	00h
8	00h	00h
9	00h	00h
10	00h	00h
11	00h	00h
12	00h	00h
13	00h	00h
14	00h	00h
15	80h	80h

C

Automatically Linked Partitioning

Today, tapes hold hundreds to thousands of gigabytes of data. Typically, the data is "stacked" on the media as different data sets and each data set has different expirations. When the expiration occurs, there is wasted space on the tape. Over time the wasted space becomes large enough where customers must reclaim the tape, which can consume many hours. To save our customers time and money, a method to capture the wasted space had to be created, hence Automatically Linked Partitioning (ALP). The tape drive created a hard disk like format such that more of the tape can be used. Tape partitioning (Non Linked) has existed for many years, however many of today's tape drives don't implement them because developers didn't think they were useful. This implementation goes beyond partitions and creates automatically linked partitions where the data can span across ALPs and be non-contiguous on tape. Furthermore the tape drive handles much of this formatting without host intervention.

The ALP feature is available only on the T10000B and T10000C and T10000D drives. It is not available on the T10000A drive. The ALP feature supports IDR (In-Drive Reclamation) and TTA (Tape Tiering Accelerator).

The T10000B tape format has 192 ALPs.

The T10000C tape format has 480 ALPs.

The T10000D tape format has 600 ALPs.

Inquiry Command

The following changes apply to the Inquiry data that can be returned.

Standard Inquiry Data

ALP Bit

The Standard Inquiry Data has been modified to return Byte 55 Bit 5 as the ALP bit.

An ALP bit set to zero indicates that the logical unit does not support the Automatic Link Partition feature. An ALP bit set to one indicates that the logical unit supports the Automatic Link Partition feature.

Erase Command

The following changes apply to Erase command.

Long bit

A long erase is not allowed on an ALP tape on a T10000B drive. A long erase is allowed on an ALP tape on a T10000C and T10000D drive.

Request Sense Command

The Request Sense command table of Sense Key with ASC and ASCQ requires the following additions:

Sense Key with ASC and ASCQ

Key	12	13	Description
5	30	05	Cannot write - incompatible format
5	3B	0C	Position past beginning of partition
5	3C	00	Command sequence error

Refer to the ALP User Manual for additional implementation guidelines.

ALP Mode Sense Command

The following changes apply to the Mode Sense data that can be returned.

Page code "11h, subpage E0 = ALP Control Mode page" to be added to the Page Code: field of the Mode Sense command description.

ALP Control Mode Page

The new mode sense page, seeTABLE C-1, returns information about the current ALP mode.

TABLE C-1 Mode Sense ALP Control mode page - T10000B

Byte	Bit 7	6	5	4	3	2	1	0
0	PS(0)	SPF(1)	Page Code (11h)					
1	Subpage Code (E0h)							
2 thru 3	Page Length (0442h)							
4	Reserved			LINKS	W_MSK	RSVD	ALP_T	ALP_C
5	Reserved							
6 thru 69	(MSB) ALP Write Mask (LSB)							
70 thru 1093	(MSB) ALP Linkage Report (LSB)							

TABLE C-2 Mode Sense ALP Control mode page - T10000C

Byte	Bit 7	6	5	4	3	2	1	0
0	PS(0)	SPF(1)	Page Code (11h)					
1	Subpage Code (E0h)							
2 thru 3	Page Length (0902h)							
4	Reserved			LINKS	W_MSK	RSVD	ALP_T	ALP_C
5	Reserved							
6 thru 133	(MSB) ALP Write Mask (LSB)							
134 thru 2181	(MSB) ALP Linkage Report (LSB)							
2182 thru 2309	(MSB) ALP Lock Mask (LSB)							

Parameter	Value
LINKS: Linkage Report Valid	0 = ALP Linkage Report data is not valid. 1 = ALP Linkage Report data is valid.
W_MSK: Write Mask valid	0 = Write Mask is not valid. 1 = Write Mask is valid.
L_MSK: Lock Mask valid	0 = Lock mask is not valid. 1 = Lock mask is valid.
ALP_T: ALP Tape	0 = Loaded tape is not an ALP tape. 1 = Loaded tape is an ALP tape.
ALP_C: ALP Capable	0 = Drive is not capable of ALP. 1 = Drive is capable of ALP.
ALP Write Mask	Bit map for ALPs 0-511(T10000B) or 0-1023 (T10000C and T10000D). ALP 0 is bit 7, byte 6 0b = ALP write not allowed 1b = ALP write allowed
ALP Linkage Report	Two bytes are used to report the linkage of each ALP. Bytes 70-71(T10000B) or bytes 134-135 (T10000C and T10000D) report linkage of ALP 0. XXXXh = This ALP is forward linked to ALP XXXXh. FFFCh = ALP blank FFFDh = ALP link unknown FFFEh = ALP not used FFFFh = ALP not linked
ALP Lock Mask	Bit map for ALPs 0-1023. ALP 0 is bit 7, byte 2182 0b = ALP not locked 1b = ALP locked

ALP Format Medium Command

This vendor unique Format Medium command is used to start a new ALP logical volume. The command must be issued only after positioning the tape to the beginning of an ALP. After this Format Medium command is processed writes will start a block ID 0.

TABLE C-3 Format Medium Command

Byte	Bit							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	Page Code (04h)							
1	Reserved						Verify	Immed
2	Reserved				Format			
3 thru 4	Transfer Length							
5	RSVD	ALP	Control Byte					

Parameter	Value
Verify:	0 = Do not verify format operation.
Immed: Immediate	0 = Return status after format completes.
Format	8h = Vendor unique - start new ALP logical volume.
Transfer Length	0000h = No data is transferred for format medium command.
ALP	1 = Start new ALP logical volume.

ALP Locate Command

This vendor unique version of the Read Position command is used to read to the current ALP index.

TABLE C-4 ALP Locate Command

Byte	Bit 7	6	5	4	3	2	1	0
0	Page Code (04h)							
1	Reserved					BT	CP	Immed
2	Reserved							
3 thru 6	Transfer Length							
7	Reserved or ALP MSB							
8	ALP LSB							
5	RSVD	ALP	Control Byte					

Parameter	Value
BT: Block Address Type	0 = SCSI logical block address 1 = Vendor - specific (ignored)
CP: Change Partition	0 = Ignore partition field 1 = Change partition (required for ALP locate)
Immed: Immediate	0 = Return status when locate is complete (required for ALP locate) 1 = Return status when locate is started
Block Address	Logical block address position (must be zero for ALP locate)
Partition	ALP index - vendor unique
ALP: Locate ALP	0 = normal locate block ID 1 = vendor unique ALP locate

ALP Read Position Command

This vendor unique version of the Read Position command is used to read to the current ALP index.

TABLE C-5 ALP Read Position Command

Byte	Bit 7	6	5	4	3	2	1	0
0	Page Code (34h)							
1	Reserved					TCLP	LONG	BT
2 thru 6	(MSB) Reserved (LSB)							
7 thru 8	(MSB) Allocation Length							
9	PPI	ALP	Control Byte					

Parameter	Value
TCLP: Total Current Logical Position	0 = Return first and last block location
LONG: Long Format	0 = Return 20 bytes of data
	1 = Return 32 bytes of data (PPI only)
BT: Block address Type	0 = SCSI logical block address
	1 = Vendor specific (ignored)
Allocation Length	0000h = 20 bytes returned (PPI returns 32 bytes)
PPI: Physical Position Indicator	0 = Return Normal read position
	1 = Return Read Physical Position Indicator data
ALP	ALP vendor unique read position
	0 = Normal read position
	1 = Read ALP index

TABLE C-6 ALP Read Position Data

Byte	Bit 7	6	5	4	3	2	1	0
0	BOP	EOP	BCU	BYCU	RSVD	BPU	PERR	RSVD
1	Partition or ALP Index MSB							
2 thru 3	(MSB) Reserved or ALP Index LSB (LSB)							
4 thru 7	(MSB) First Block Location (LSB)							
8 thru 11	(MSB) Last Block Location (LSB)							
12	Reserved							
13 thru 15	(MSB) Number of Blocks in Buffer (LSB)							
16 thru 19	(MSB) Number of Bytes in Buffer (LSB)							

Parameter	Value
Partition	Partition Number
	00h = Only partition supported (regular read position)
ALP Index	Current ALP index - two bytes (ALP only)

D

SSA Command

This vendor unique command is used to search for information on the currently mounted media. All searches are initiated at the current device location. The search is complete when the specified search data is found, EOD is detected, or a filemark is encountered (see option flags).

TABLE D-1 SSA Command

Byte	Bit 7	6	5	4	3	2	1	0
0	Operation Code (C5h)							
1	Reserved							
2 thru 4	Data Block Offset							
5	Reserved			SOFM	Reserved			DBOE
6	Reserved							
7	Reserved							
8 thru 9	(MSB) Search Data Length (LSB)							
10	Reserved							
11	Control Byte							

.

TABLE D-2 SSA Data Format

Byte	Bit 7	6	5	4	3	2	1	0
0 thru 1023	(MSB) Data Block Offset (LSB)							

Parameter	Value
Data Block Offset	When enabled by the option flags below, this offset indicates the exact position in a data block where the search should find the specified search data. If the search data is not found at the exact specified offset, then the search proceeds to the next data block (if one) and examines that block at the exact specified offset (and so on until an EOD or a filemark is encountered per the option flags below). This type of search is useful for finding unique customer metadata on the currently mounted media. The data block offset + the search data length should not be greater than the maximum block length - 1 as data block spanning is not supported on the T10KC. Offset values can range from 0 to the maximum block length - 1. Maximum block length is 2,097,152 bytes (0x200000) in standard mode. Maximum block length is 2,097,156 bytes (0x200004) in DIV mode.
Option Flags	Search options - Stop On Filemark (SOFM) and Data Block Offset Enable (DBOE) 00 = A search for the specified search data is initiated at the current device location. The search is stopped when the search data is found or EOD is encountered 01 = The drive will determine if the specified search data exists at the exact specified offset in a data block starting at the current device location. If it does not, then the search proceeds to the next data block. The search is stopped when the search data is found at the exact specified offset or an EOD is encountered. 10 = The same as option 00, but will also stop if a filemark is encountered. 11 = The same as option 01, but will also stop if a filemark is encountered.
Search Data Length:	The search data length specifies the size of the search data. The data block offset + the search data length should not be greater than the size of a data block as data block spanning is not supported on the T10KC. Values ranges from 1 to 1024 bytes.
Search Completion:	If a match is found: The drive is positioned BEFORE the data block that contains the match. If a match is not found: For option flags 00 & 01: The drive is positioned at EOD. For option flags 10 & 11: The drive is positioned AFTER a filemark if one is found, otherwise EOD.

E

Fibre Channel over Ethernet

The following Fibre Channel over Ethernet (FCoE) information was extracted from an Oracle White Paper, dated March 2010, titled *Ethernet: The Drive for Convergence*.

Executive Overview

Convergence of networking technologies is a long held requirement for IT managers. The benefits gained by having a single infrastructure for data networking, storage networking, and inter-processor communications provide improved Total Cost of Ownership (TCO). This is due to the use of common hardware for multiple network traffic types as well as direct cost savings from eliminating redundant management tools and systems for separate networks.

Past attempts at delivering a networking convergence technology did not materialize because the available solutions could not meet either the performance or investment protection requirements demanded by users. These failing technologies met one or the other of these requirements, but not both.

The adoption of 10 Gigabit Ethernet into mainstream data centers now makes it possible for Ethernet to match the raw performance characteristics of Fibre Channel (FC) Storage Area Networks (SANs). This development has given the industry the opportunity to develop a convergence technology based on the ubiquitous and familiar Ethernet networking standard that can also meet the needs of the storage networking market. This new technology is commonly referred to as Enhanced Ethernet (EE) or Converged Enhanced Ethernet (CEE). The standard that enables SANs to operate on Ethernet is known as Fibre Channel over Ethernet (FCoE). These emerging networking technologies will enable the next generation, lower cost, flexible, virtualized data centers of the future.

Fibre Channel over Ethernet

FCoE is a new ANSI T11 standard for the encapsulation of a complete FC frame into an Ethernet frame. The resulting Ethernet frame is transported over Ethernet networks. The SCSI encapsulation in the FC frame does not require the implementation and processing overheads of TCP/IP based SCSI protocols like iSCSI and iFCP.

Fibre Channel is designed to provide reliable high performance operation in a loss-less network. However, Ethernet does not have such loss-less characteristics. One solution is to implement Fibre Channel on an Ethernet fabric that implements 802.3

Annex 31B pause-based flow control. This is a potential solution. However, it does not address the need for convergence of multiple traffic flows on Ethernet, as this flow control mechanism will stop all traffic rather than only the specific traffic that requires flow control. The industry is working on defining two standards to address these issues that, when combined, will make Ethernet a loss-less network with traffic isolation between classes of service.

The two additional technologies in development that will enable both high reliability and network convergence are Priority Based Flow Control and 802.1au Congestion Management. These technologies are described in the following paragraphs.

Priority Based Flow Control

Priority Based Flow Control enables separated traffic classes on a single fabric by enabling an Annex 31B pause "like" mechanism for each traffic class flow. This solution allows the designated higher priority traffic to flow at the same rate, while lower priority traffic may be temporarily paused when congestion occurs. The technology thus separates the different traffic flows based on their characteristics on an Ethernet network. For example, the storage and LAN traffic are separated and so are SAN and IPC traffic.

IEEE 802.1au - Congestion Management

The IEEE 802.1au Congestion management is the second key component required to enable a converged Ethernet fabric. In an Ethernet network, packet loss typically occurs due to network congestion. The network congestion is "solved" by dropping packets. Congestion Management will control packet insertion into the network to mitigate congestion in the fabric.

Glossary

This glossary defines terms and abbreviations used in this manual. For definitions of other Fibre Channel or StorageTek terms refer to the glossary in the appropriate document.

Numbers

8B/10B
A type of encoding and decoding algorithm of bytes, invented and patented by IBM, to reduce transmission errors. This algorithm was adopted as part of the FC-PH-1 Standard in 1991.

A

Abort Exchange (ABTX)
The Abort Exchange command can be used with Abort Sequence - Last Sequence (ABTS - LS) (SCSI-PLDA), by itself, or with ABTS Fibre Channel Link Encapsulation (FC-LE) protocol. The Abort Exchange Command used in the Extended Link Services, and is prohibited when originated by the initiator, and is prohibited when originated by a drive.

Abort Sequence (ABTS)
The protocol that is invoked by devices supporting the Fibre Channel Protocol for SCSI to abort the exchange whenever a Sequence Error is detected. It comes in two protocols: Abort Sequence - Last Sequence (ABTS - LS) (SCSI-PLDA), by itself, or with ABTS Fibre Channel Link Encapsulation (FC-LE).

ABTS
See Abort Sequence (ABTS).

ABTX
See Abort Exchange (ABTX).

ACA
Auto Contingent Alliance.

ACC
Accept.

ACK
See Acknowledge.

Acknowledge
A response or confirmation to an address, message, or poll.

Additional Sense Bytes
The additional sense bytes contain data specific to either or both the command or peripheral device, and further define the nature of the FCP_SNS_INFO feature of the FCP_RSP payload.

Addressing Scheme
The order in which node and port names are presented to the recipient in a Fibre Channel transaction.

ADISC
See Discover Address (ADISC).

ADVC
See Advise Credit.

Advise Credit
The Advise Credit Command used in Extended Link Services. It is prohibited when originated by the initiator, and prohibited when originated by a drive.

AEN
See Asynchronous Event Notification.

AL_PA
See Arbitrated Loop Physical Address.

AL_PD
Arbitrated Loop physical destination address.

AL_PS
Arbitrated Loop physical source address.

AL_TOV
Arbitrated loop timeout value.

Allowable
A function of Fibre Channel that allows a feature or parameter to be used between an initiator and a target.

American National Standards Institute
A standards development organization that is not associated with the U.S. government, but that develops standards that can be used voluntarily by product vendors in the United States. The name of the organization was recently changed to the National Committee for Information Technology Standards (NCITS).

ANSI
See American National Standards Institute.

APPTC
Application Tag Check.

Arbitrate to win loop
In an arbitrated loop topology, the process that a port performs to select another port to send data to or receive data from that same port.

Arbitrated Loop

A topology in Fibre Channel that provides multiple connections for devices that share a single loop, over which only two devices can communicate at once. Similar to the SCSI protocol of the same name, it provides an “arbitrate and win” scenario between more than two devices when those devices want to communicate on the bus. The sending device must arbitrate and win the connection with the receiving device before communication can begin.

Arbitrated Loop Physical Address

A one-byte value that identifies a port in an arbitrated loop topology.

arbitration

Any process by which a user of a shared resource negotiates with other users for the right to use the resource. A port connected to a shared bus must win arbitration before it transmits data on the bus.

Asynchronous Event Notification

A form of communication used between processes to notify a process of an asynchronous action, such as an input/output activity or message transmission.

B

b

The abbreviation for bit.

B

The abbreviation for byte.

BB_Credit

See Buffer-to-Buffer Credit.

Buffer Size

The amount of storage space allocated to the buffer, which is a storage space reserved temporarily for a given purpose. In Fibre Channel, this buffer is usually larger than a single frame, up to the size of an entire sequence.

Buffer-to-Buffer Credit

This is a value which is managed by the R_RDY primitive signal on a link, and is used by a transmitter to determine the permission to transmit frames. If permission is granted by the recipient, this value also tells the transmitter how many are permitted. The transmitter may transmit a frame when Available BB_Credit is greater than 0. This differs from End_to_End Credit.

Buffer-to-Buffer

A method of transferring information in which neither the initiator nor receiver of the information knows the contents.

Byte

A group of eight bits.

C

CDB

Command descriptor block. A structure for SCSI commands.

Channel
An I/O interface between a central processor and peripheral device in which large amounts of data are transferred at the highest rate of speed possible for the transmission medium.

Class of Service
The Fibre Channel method of defining a data transmission strategy between devices. There are three FC Classes of Service currently specified in the FC-PH-1, and StorageTek's implementation includes only one, Class 3.

Class 3
The Fibre Channel Class of Service in which the initiator sends a message to a receiving device without expecting or requiring an acknowledgement. It is analogous to the human communication method of sending an advertisement in hopes that the message is received.

CLS
Close.

Company ID
A unique address in IEEE proposed format.

Control Byte
The last byte of every Command Descriptor Block. The Control Byte contains two vendor-specific bits, four reserved bits, one flag bit, and one link bit.

CRC
See Cyclic Redundancy Check.

Cyclic Redundancy Check
A mechanism used for error detection that calculates a numeric value by using a special algorithm applied to a series of bytes that are generally appended to the data. If no error has occurred when the receiver executes the algorithm on the received data, the newly generated CRC value should be the same as the CRC value originally transmitted.

D

Delimiter
In FC, a special transmission word that marks either the beginning, or ending, of a frame in an FC transmission.

Deserialization
The process of receiving data, one bit at a time, and re-compiling it into a larger data unit, such as a transmission character or a byte.

Destination Address
In the frame header of each frame transmitted, the destination address is a value that identifies the port in a node that is to receive the frame.

Device Addressing
One of two levels of addressing in an I/O interface, the other being link-level. Device addressing identifies the channel or control unit when the control unit has been determined through link-level addressing.

Device management
Defines communications for transferring data between initiators and recipients using FCP_CMND, FCP_XFER_RDY, FCP_DATA, and FCP_RSP information units (IUs).

DF_CTL
Data field control indicates optional headers in the frame.

DIF
Data Integrity Field.

DIV
Data Integrity Validation.

Disassembly
The process of splitting out a source buffer into payloads. These payloads are then transmitted in frames.

Discover Address (ADISC)
The Discover Address command used in Extended Link Services. It is invokable when originated by the initiator, required as a response by the drive, and prohibited when originated by a drive.

Discover F_Port Parameters (FDISC)
The Discover F_Port Parameters command used in Extended Link Services. It is prohibited when originated by the initiator, and prohibited when originated by a drive.

Discover N_Port Parameters (PDISC)
The Discover N_Port Parameters command used in Extended Link Services. It is invokable when originated by the initiator, requires a response by the drive, and is prohibited when originated by a drive.

Disparity
A form of error detection for frame transmission. Running disparity adds a second dimension to the transmission of characters that provides a balance of ones and zeros and helps protect transmission characters and controls the heat output of the transmitter.

Drive Response
One of the functions of Extended Link Services.

E

E_D_TOV
See Error Detect Timeout Value.

Echo
The Echo command used in Extended Link Services. It is prohibited when originated by the initiator, and is prohibited when originated by a drive.

ECMA
European Computer Manufacturers Association

Encoding
The process used to change the original form in which information is available, into another form. An example of this is changing handwritten text into computer bytes.

End-of-Frame Delimiter
A special transmission word in a frame used to mark the end of that frame.

Enterprise System Connection (ESCON)
An IBM-patented set of products and services that provide a dynamically connected environment, over fiber optic cable, within a mainframe or client server enterprise.

EOF Delimiter
See End-of-Frame Delimiter.

EOFa
End of frame abort.

EOFn
End of frame normal.

EOFni
End of frame normal invalid.

EOFt
End of frame terminate.

Error Detect Timeout Value
The minimum period of time that an L_Port can wait for the sequence to complete before initiating a recovery action.

ESCON
Enterprise Systems Connection.

Establish Streaming (ESTS)
The Establish Streaming command used in Extended Link Services. It is prohibited when originated by the initiator, and prohibited when originated by a drive.

ESTC
Estimate Credit command.

Estimate Credit (ESTC)
The Estimate Credit command used in Extended Link Services. It is prohibited when originated by the initiator, and prohibited when originated by a drive.

ESTS
See Establish Streaming (ESTS).

Exchange
The administrative layer that controls overall operations across FC. An exchange is established when an N_Port sends a sequence of at least one frame to another N_Port.

Exchange Identifier
The field (OX_ID) in the frame header that identifies a process in the source during a transmission from one N_Port to another. An exchange is established between the N_Ports when the first frame of a new operation is accepted by the destination N_Port.

F

F_CTL
Frame control. Controls information within a frame. A portion of the FC-2 Sequence Chaining feature.

F_Port
A port within the Fabric which attaches to an N_Port through a link.

Fabric
The FC topology that is similar to a telephone switch in that the initiator of a “call” to the receiving port simply provides the receiver with the port address, and the fabric routes the transmission to the proper port. A fabric differs from a point-to-point or arbitrated loop topology in that it provides for interconnections between ports without having a point-to-point connection. The fabric also serves as a media type converter.

FACT
Fabric active alias_ID.

FAN
Fabric address notification.

Fault Symptom Code
Four hexadecimal digits that identify a cartridge subsystem error.

FC
Fibre Channel.

FC_AL
Fibre Channel Arbitrated Loop standard.

FC-PH-1
The FC Physical and Signaling Interface defined in the ANSI X3.230-1994.

FC-PH-2
An extension of the FC Physical and Signaling Interface defined in the ANSI X3.230-1994 that specifies several extra protocol levels.

FC-0
The level of the FC-PH-1 Standard that defines the physical level. FC-0 defines the media types and connectors, as well as the electrical and optical characteristics, necessary for connecting ports. This level can be found in the FC-PH-1 Standard, clauses 5 to 10, and 12 to 15.

FC-1
The level of the FC-PH-1 Standard that defines the transmission protocol. FC-1 includes the 8B/10B encoding/decoding scheme, word order transmission, and error detection. This level can be found in the FC-PH-1 Standard, clauses 11, 16, and 17.

FC-2
The level of the FC-PH-1 Standard that defines the framing and signaling protocol. FC-2 includes the frame layout, frame header content, and rules for use. This level can be found in the FC-PH-1 Standard, clauses 18 to 29.

FC-3
The level of the FC-PH-1 Standard that defines the common services level that may be available across multiple ports in a node. This level has no current standard in the FC-PH-1 Standard.

FC-4
The level of the FC-PH-1 Standard that defines the mapping of protocols between the lower levels of FC, and the command sets that use FC. Separate standards exist for SCSI-3, IP, IPI-3, HIPPI, and others.

FCoE
The standard that enables SANs to operate on Ethernet.

FCP
See Fibre Channel Protocol.

FCP_CMND
Fibre channel SCSI-3 command service request.

FCP_DATA
The action of delivering data.

FCP_RSP
SCSI-3 response such as Status.

FCP_XFER_RDY
The request for date.

FDACT
Fabric deactivate alias_ID

FDDI
See Fiber Distributed Data Interface (FDDI).

FDISC
See Discover F_Port Parameters (FDISC).

Fiber
A wire or strand of optical cable. Fiber is spelled “Fibre” in Fibre Channel.

Fiber Distributed Data Interface (FDDI)
An NCITS standard for transmitting data at 100 mega-baud over fiber optic cable.

Fiber Optic Cable
A jacketed cable of thin strands of glass which carry pulses of light that transmit data for high-speed transmissions over medium to long distances. The cable can be single mode, which carries a single signal from a laser or LED light source, or multi-mode, which carries multiple signals from either light source.

Fibre Channel
The ANSI standard that defines an ultra high-speed, content independent, multi-level data transmission interface that can support multiple protocols simultaneously, support connectivity to millions of devices over copper and/or fiber optic physical media, and provides the best characteristics of both networks and channels, over diverse topologies.

Fibre Channel over Ethernet
See FCoE.

Fibre Channel Physical and Signaling Interface (FC-PH-1)
See FC-PH-1.

Fibre Channel Protocol
The mapping of SCSI-3 commands over a fibre channel interface.

FIFO
First in first out.

Fill Word
A word transmitted between frames containing no information essential to either frame. The fill words are defined by the topology. The Idle primitive signal is an example of a fill word.

FIXED
Indicates the block mode for data transfer.

FL_Port
An F_Port within the Fabric which also contains the Loop Port State Machine as defined in FC-AL-2. The FL_Port attaches to an NL_Port through a link.

FLOGI
Fabric Login.

Flow Control
The process of limiting the number of single frames or groups of frames received by the receiving port. This is accomplished using a credit system. *See* Buffer-to-Buffer Credit (BB_Credit) and End-to-End Credit (EE_Credit).

Frame
An indivisible, encapsulated data structure containing a beginning-of-frame (BOF) and end-of-frame (EOF) designator, which carries a payload of both control data and user data from one FC port to another.

Frame Header
The first field in a frame that contains addressing information, as well as other control information, about the frame.

FRU
Field replaceable unit.

FSC
See Fault Symptom Code.

Full Duplex
A communication protocol that allows signals to be transmitted and received simultaneously, and usually contains flow control.

G

GAID
Get alias_ID.

GBIC
Giga-bit interface converter.

GRDC
Guard Check

H

Half Duplex
A communications protocol that permits a port to transmit or receive frames at any point in time, but not simultaneously, as in full duplex. The one exception to this is with link control frames, which are always allowed in full duplex.

HBA
See host bus adapter (HBA).

Header Data

The part of a message that contains system-defined control information. This data may contain, but not be restricted to, one or more destination fields, initiator and receiver address, and priority level of the message.

Hexadecimal

A number system with a base of 16 instead of 10.

High Performance Parallel Interface

The NCITS standard that defines high-speed information transfer using dual simplex, over a short parallel bus.

HIPPI

See High Performance Parallel Interface.

Host

A processor, usually composed of a CPU and memory, that typically communicates with peripheral devices over channels and/or networks, to perform I/O operations such as network control. It also provides end users with computation services and database access.

host bus adapter (HBA)

A circuit installed in a multi-platform host or device that interfaces between the device and the bus.

HSSDC

High speed serial data connectors. StorageTek tape drives use this type of connector at the interface card.

Hub

A piece of hardware, separate from the actual FC interface accessible on the backplane of a device, which houses the port bypass circuitry for configurations of 8 to 16 ports per hub. Hubs may be stacked to support larger configurations, and can usually support a mix of both electrical and optical media ports in the same hub.

I

IEEE 802.1au Congestion management

The IEEE 802.1au Congestion management is the second key component required to enable a converged Ethernet fabric.

Idle

A special type of fill word sent from a transmitting port to a receiving port that contains no data or control information, but communicates that the transmitting port has more frames to send. The idle word is necessary because FC needs a continuous flow of transmissions and receptions to remain operational.

ILI

Illegal length indicator.

Inbound Fiber

The fiber in a link that carries information into a receiving port.

Information Unit

A unit of information defined by FC-4 mapping transferred as sequences.

Intelligent Peripheral Interface
The NCITS standard used in host computers to control peripheral devices at a speed of up to 100 MB/s. In its FC implementation, IPI remains half-duplex within I/O operations.

Internet Protocol
A stacked set of protocols, developed by the U.S. Department of Defense, to facilitate communication between dissimilar computers over networks.

Invokable
A function of Fibre Channel that allows a feature to be used between an initiator and a recipient (such as cartridge subsystem). Thus, if a feature or parameter is invoked, the recipient must implement and respond to the feature or parameter.

IP
See Internet Protocol.

IPI
See Intelligent Peripheral Interface.

ips
Inches per second, a tape movement measurement.

IU
See Information Unit.

J

Jitter
The deviation of timing in an exchange.

L

L_Port
It is either an FL_Port or an NL_Port.

Laser
A term meaning Light Amplification by Stimulated Emission of Radiation. Laser devices generate coherent radiation in the visible, ultraviolet, and infrared portions of the electromagnetic spectrum. Regarding FC, lasers can be transmitting either short waves or long waves, depending on the composition of the arbitrated loop or fabric.

LC connector
A standard connector for 2 Gbps Fibre Channel data transfer. This type of connector is used on fiber-optic cables.

LIFO
Last in first out.

Link
A two-fiber connection made between two FC ports in which one fiber is transmitting, the other receiving, information.

Link Bit
The link bit allows the initiator to "link" or continue the input/output process. This bit allows devices that support command linking to indicate to the initiator that the command was accepted by returning a status of "Intermediate" to the initiator.

Link Service

The set of commands used by FC to manage functions such as port management, login/logout, and abort operations. There are both basic and extended link services, which StorageTek cartridge tape subsystems support.

Link Services Command Reject

The code returned by a recipient device (such as a cartridge subsystem) receiving a request for Extended Link Services which are unsupported. The recipient returns a reason code of "Command not supported."

Linking

(1) The activity of connecting one inbound fiber and one outbound fiber to a port. (2) The activity of linking commands, as identified in the INquiry data, where the flag bit of the Command Descriptor Block is set to zero.

LIP

See Loop initialization primitive.

LIRP

Loop Initialization Report.

LIS_HOLD_TIME

Loop Initialization Sequence Hold time.

LISM

Loop Initialization Select Master.

Login

The FC-required process used by any initiating N_Port or NL_Port in an FC fabric to sign in with any other receiving N_Port or NL_Port port with which it plans to communicate. The signing in process provides the initiator with critical information about the attributes of the recipient port before it attempts to make a connection with it.

Login_BB_Credit

On an Arbitrated Loop, this signal is the value equal to the number of receive buffers that a recipient NL_Port guarantees to have available once a loop circuit is established. Login_BB_Credit is communicated via the FLOGI, PLOGI, or PDISC Extended Link Services.

Logout

An Extended Link Services command that terminates all open Exchanges with the SCSI initiator and its target. LOGO is invokable when originated by the initiator, requires a response by the drive, required when originated by the drive, and requires a response by the initiator.

LOGO

See Logout.

Loop initialization primitive

Assigns up to a possible 127 addresses to different ports on the loop and builds a map of these addresses.

LPSM

Loop port state machine.

LRC

Longitudinal redundancy check.

LSB
Least Significant Bit.

LS_RJT
See Link Services Command Reject.

LUN
Logical unit number. A SCSI device address.

M

MB
Abbreviation for megabyte (2^{20} or 1,048,076 bits).

MB/s
Abbreviation for megabytes per second.

Mb/s
Abbreviation for megabits per second.

MB/sec
Abbreviation for megabytes per second.

Mb/sec
Abbreviation for megabits per second.

Mode Select Command
The command used in Fibre Channel that specifies operational parameters and options for a logical unit. The fields that can be changed by the Mode Select Command and what the default values are for these fields.

MSB
Most Significant Bit.

multi mode
A graded-index or step-index optical fiber that allows more than one bound mode to propagate. Contrast with single mode.

multimode fiber
An optical fiber designed to carry multiple signals, distinguished by frequency or phase, at the same time.

N

N_Port
A Port within the node that attaches to a link.

N_Port ID
The identifier of an N_Port in a point-to-point or fabric FC topology.

N_Port Login (PLOGI)
The N_Port Login command used in Extended Link Services. It is required when originated by the initiator, requires a response by a drive, and is prohibited when originated by a drive.

Nanometers (nm)
One billionth meters.

National Committee for Information Technology Standards
Formerly the American National Standards Institute (ANSI).

NCITS
See National Committee for Information Technology Standards.

Network
An arrangement of nodes and branches, connecting data processing devices to one another via software and hardware links, to facilitate information interchange.

NL_Port
An N_Port within the Node which also contains the Loop Port State Machine as defined in FC-AL-2. The NL_Port attaches to either an FL_Port or an NL_Port through a link.

nm
Abbreviation for nanometers.

No Operation (NOP)
The No Operation command used in Basic Link Services. It is prohibited when originated by the initiator, and prohibited when originated by a drive.

Node
A device that contains a minimum of one N_Port or NL_Port.

Node Name
A 64-bit concatenation of the Port Name, Company ID, and drive serial number, in an IEEE extended format.

NOP
See No Operation (NOP).

O

Operation Code Structure
A component of the Command Descriptor Blocks that compose Byte 0 of both the 6-Byte and 10-Byte Command Descriptor.

OPN
Open.

Ordered Set
Special types of transmission words, either fill words or control words, that have special meanings in a transmission. Ordered sets include primitive signals, primitive sequences, and frame delimiters.

Originated by Drive
An action taken by the recipient of either a Basic Link Service Command, or an Extended Link Service Command. These actions can be Allowable, Invokable, Prohibited, or Required.

Originated by Initiator
An action taken by the initiator of either a Basic Link Service Command, or an Extended Link Service Command. These actions can be Allowable, Invokable, Prohibited, or Required.

Outbound Fiber
The fiber in a link used to transmit information to a receiving port.

OX_ID
Originator exchange identifier.

P

Parallel Transmission
The transmission of bits over multiple fibers, either copper or glass, all at one time, and accomplished by dedicating each fiber to transmitting one bit at a time. This high speed transmission method is good for short distances only. Contrast with serial transmission.

Payload
The portion of the data field in a frame, not part of the optional header data, that contains the substantive information being transmitted between ports in FC.

PDISC
See Discover N_Port Parameters (PDISC).

PLDA
See Private Loop Direct Attach.

PLOGI
See N_Port Login (PLOGI).

Point-to-Point
A topology in which exactly two ports communicate. In FC, the two ports are N_Ports.

Port
A specific end-point for communications within a host, or from a host to a peripheral device or vice versa. In FC, it is an access point in a device where a link attaches. Examples of this port are N_Port, NL_Port, F_Port, and FL_Port.

Port Addressing
In FC, Port Addressing is used for login validation, and includes the Port Name, Node Name, and N_Port ID.

Port Name
A 64-bit word consisting of the port number, Company ID, Tape Drive Number, and zeros.

Primitive Sequence
A special type of ordered set transmission word sent repeatedly by a port until a proper response is received. The primitive sequence signals specific conditions such as online to offline, or link reset. *See* Ordered Set.

Primitive Signals
A type of ordered set that is transmitted by a port, outside the confines of a frame transmission, to do a specific function not associated with transmitting data per se. Examples are Idle and Receiver Ready (R_RDY). A receiving port recognizes a primitive signal when it is received as a single entity, not grouped with other signals.

Priority Based Flow Control
Enables separated traffic classes on a single fabric by enabling an Annex 31B pause "like" mechanism for each traffic class flow.

Private Loop
An Arbitrated Loop that does not contain a participating FL_Port but does contain two or more NL_Ports.

Private Loop Direct Attach
Defines a subset of standards for operations of serial devices (tape drives) on a private loop.

Private NL_Port
An NL_Port that does not attempt a Fabric Login.

PRLI
See Process Login.

PRLO
See Process Logout.

Process Login (PRLI)
The Process Login command used in Extended Link Services. It is required when originated by the initiator, requires a response by a drive, and is prohibited when originated by a drive.

Process Logout (PRLO)
The Process Logout command used in Extended Link Services. It is invokable when originated by the initiator, requires a response by a drive, is invokable when originated by a drive, and requires a response by an initiator.

Prohibited
The state of a function, parameter, or operation of FC not being allowed to be used between an initiator and a target.

Protection Information
Protection information can be generated by a Disk storage controller or it can be generated at the application layer and may be checked by any object associated with the I_T_L nexus (see SAM-4). Once received, protection information is retained (for example, written to medium, stored in non-volatile memory, or recalculated on read back) by the device server until it is overwritten. Power loss, hard reset, logical unit reset, and I_T nexus loss shall have no effect on the retention of protection information.Protection Information is also referred to as theData Integrity Field (DIF) or Data Integrity Validation (DIV).

Public Loop
An Arbitrated Loop that includes a participating FL_Port and at least one NL_Port.

Public NL_Port
An NL_Port that attempts a Fabric Login.

Q

QoSR
Quality of service request.

R

R_A_TOV
See Resource Allocation Timeout.

R_CTL
The Routing Control field in the frame header contains a routing bits sub-field, which has specific values indicating that FC-4 data will follow. It also contains an information category field, which indicates to the recipient the type of data that the frame contains.

R_RDY
Receiver Ready.

R_T_TOV
Receiver Transmitter timeout value.

RCS
Read connection status block.

Read Exchange Status Block
The Read Exchange Status Block command used in Extended Link Services. It is restricted when originated by the initiator, restricted when originated by a drive, and invokable when originated by a drive.

Read Link Error Status Block
The Read Link Error Status Block command used in Extended Link Services. It is invokable when originated by the initiator, allowable when originated by a drive, and prohibited when originated by a drive.

Read Sequence Status Block
The Read Sequence Status Block command used in Extended Link Services. It is invokable when originated by the initiator, allowable when originated by a drive, and prohibited when originated by a drive.

Read T10 PI (16)
The Read T10 PI (16) command requests that the device server transfer the next record or records from tape to the host. After successful completion of a read operation, the tape is positioned after the last block read. Each block transferred includes user data and protection information.

Receiver Read
A primitive signal used in flow control by a receiving port to indicate to the transmitting port that the receiving port is ready to receive more information.

REFTC
Reference Tag Check.

Reinstate Recovery Qualifier (RRQ)
The Reinstate Recovery Qualifier Command used in Extended Link Services. It is invokable when originated by the initiator, requires a response by a drive, is prohibited when originated by a drive.

Remove Connection
The Remove Connection Command used in Basic Link Services. It is prohibited when originated by the initiator, and is prohibited when originated by a drive.

Report Node Capabilities Information
The Report Node Capabilities Information Command used in Extended Link Services. It is invokable when originated by the initiator, requires a response by a drive, is prohibited when originated by a drive.

Request Sequence Initiative
The Request Sense Initiative Command used in Extended Link Services. It is invokable when originated by the initiator, allowable as a response by a drive, is required when originated by a drive, and requires a response by an initiator.

Required
The state of a function, parameter, or operation of FC required to be implemented by both the initiator and target.

RES
See Read Exchange Status Block.

Resource Allocation Timeout
The minimum amount of time that an L_Port waits before reinstating the Recovery Qualifier.

Resource Recovery Timeout
The minimum amount of time a target waits for an ADISC or PDISC Extended Link Service following a LIP

RLS
See Read Link Error Status Block.

RMC
See Remove Connection.

RNC
See Report Node Capabilities Information.

RR_TOV
See Resource Recovery Timeout.

RRQ
See Reinstate Recovery Qualifier (RRQ).

RSCN
Registered state change notification.

RSI
See Request Sequence Initiative.

RSS
See Read Sequence Status Block.

RTV
Read timeout value.

RX_ID
Responder exchange identifier.

S

SC connector
A standard connector for 1 Gbps Fibre Channel data transfer. This type of connector is used on fiber-optic cable.

SCN
State change notification.

SCSI
See Small Computer System Interface.

SCSI Commands
The SCSI-3 Fibre Channel Protocol (FCP) commands issued by either the initiator or target in an arbitrated loop topology, to perform a specific SCSI task. There is a direct correspondence between the SCSI task and the FC exchange. A Fibre Channel exchange can correspond directly to either a single SCSI command, or group of linked SCSI commands.

SCSI-3
The set of SCSI commands used for Fibre Channel. SCSI-3 comes in a Generic Packetized Protocol (SCSI-3 GPP) and Fibre Channel Protocol (SCSI-3 FCP).

SEQ_CNT
See Sequence Count.

SEQ_ID
See Sequence Identifier.

Sequence
A set of one or more frames identified as a unit within an interchange.

Sequence Count
A value in a frame header that helps the receiving port identify the order in which a set of frames was transmitted.

Sequence Identifier
In a transmission between a pair of terminal N_Ports, the field in the Sequence Content header portion of the Sequence Management frame that separates one sequence from another. *See* SEQ_ID.

Serial Transmission
A transmission in which bits are sent in a stream in a single fiber. Contrast this with a parallel transmission.

SFP
See small form-factor pluggable.

SILI
Suppress Illegal Length Indication

single mode fiber
Optical fiber in which only the lowest-order bound mode can propagate at the wavelength of interest.

Small Computer System Interface
An input and output bus that supports the attachment of various devices to operating systems. Fibre Channel uses the SCSI-3 command set.

small form-factor pluggable
Technology with 2-gigabit transfer speed over small connectors, cables, and transceivers for larger bandwidth capability.

SOF
See Start-of-Frame Delimiter.

SOFi3
The abbreviation for Start of Frame Initiate Class 3 delimiter.

SOFn3
The abbreviation for Start of Frame Normal Class 3 delimiter.

Start-of-Frame Delimiter
A delimiter used to mark the beginning of a frame, as well as specify the class of service used for the frame.

switch
In Fibre Channel technology, a device that connects Fibre Channel devices together in a Fabric.

T

T10 PI model
The T10 PI model provides for protection of user data while it is being transferred between a sender and a receiver.

task management
Defines when a task or group of tasks must be aborted or terminated.

Third Party Process Logout
The Third Party Process Logout Command used in Extended Link Services. It is invokable when originated by the initiator, requires a response by a drive, is prohibited when originated by a drive.

Topology
A method or scheme for connecting ports for communicating in FC. FC topologies include Point-to-Point, Arbitrated Loop, and Fabric.

TPRLO
See Third Party Process Logout.

Transfer Length
Number of blocks or bytes requested.

Transmission Word
A four-byte character containing 32 bits of information, which is the smallest information unit transmitted on Fibre Channel.

U

ULP
Upper level protocol.

ULP_TOV
Upper Level Protocol timeout value.

V

VBF
Verify By Filemarks

VLBPM
Verify Logical Block Protection Method

VolSafe
A Sun StorageTek feature that provides write once, read many (WORM) technology to VolSafe-designated tape cartridges. VolSafe only permits new data to be appended to data currently on the tape. Once written, the data cannot be overwritten.

VTE
Verify To End-of-data.

W

World Wide Name (WWN)
A 64-bit integer that identifies a Fibre Channel port.

World Wide Node Name (WWNN)
A 64-bit network address that identifies the company (in IEEE format) with a vendor specific identifier.

World Wide Port Name (WWPN)
A 64-bit network address that identifies the port name.

Write T10 PI (16) command
The Write T10 PI (16) command transfers one or more blocks of data from the host to tape. After successful completion of a write operation, the tape is positioned after the last block written. Each block transferred includes user data and protection information.

X

X_ID
A Class 3 Service Parameter used for Recipient Control. It contains one word with 29 bits, and a value of 0.

x
Hexadecimal notation.

XFER
Transfer.

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